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OWNERSHIP, TECHNOLOGY AND PATTERNS OF COALMINING ACTIVITY IN NORTHUMBERLAND BETWEEN 1600 AND 1850

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ABSTRACT

This thesis attempts to describe and explain the spatial changes which occurred in the development of coalmining in Northumberland between 1600 and 1850. The explanation is derived from an examination of primary and published sources of various types, of which colliery records, documents and plans have been the most important. The study is divided into two main parts. The first is concerned with the movement of mining away from the outcrops into areas of deeper coal culminating in the colonisation of the remoter coalfield. It begins in the early seventeenth century when mining was confined to a few manors on the banks of the Tyne and traces chronologically the great changes in the nature, scale and location of the industry which occurred during the ensuing two-and-a-half centuries. The second part analyses the major influences which controlled the location and movement of mining, dealing primarily with the roles of land and colliery ownership and of changing technology. In conclusion an attempt is made to evaluate the predictability of the mining process and to assess its amenability to model-building and generalisation.

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I am grateful also to Mr H.C. Prince for acting as my external adviser and for facilitating relations with the university. In addition I would like to express my gratitude to Dr B.K. Roberts and Mr R.A. Butlin who gave me early advice on the delimitation of a field of research in the north of England.

Last, but not least, I would like to thank Mrs J Sturdy, who did the final typing and Miss E Dawlings, who prepared some of the maps.

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Abbreviations used in the footnotes:

NEIMME North of England Institute of Mining and Mechanical Engineers

NRO Northumberland County Record Office

PRO Public Record Office

CHAPTER ONE

INTRODUCTION

In January 1974 contractors working for the Tyneside Joint Sewerage Board discovered old mineworkings below South Eldon Street in South Shields. The National Coal Board estimated that they dated to 'before 1750'. The Shields Gazette described them as follows:

> They comprise two 20ft.long galleries lying on either side of a sewer heading connected by a 10ft.cross-link. Approximately 6ft.wide and 4ft.high, the roof of the workings lies some 16ft.below the surface of the road in a layer of coal and mudstone topped by limestone [1].

Before this accidental discovery no mineworkings of this early, shallow type were known to exist in this district [2]. Not surprisingly the South Shields Borough Engineer, Mr. H. Gourlay, recommended that a geological investigation of the area be made before further redevelopment was planned.

Yet such workings are easy to explain. Before the eighteenth century the Tyneside salt industry, four-fifths of which was located along the South Shields riverside, was probably the greatest industrial consumer of coal in the world [3]. In the later seventeenth century when the industry reached its zenith, annual consumption was in the region of

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1. Shields Gazette, 'Workmen dig up old mine', January 19th 1974, p 6.
2. Temple Main Colliery, opened during the last years of the eighteenth century, is the earliest documented mine in South Shields.
3. P. PILBIN, 'A Geographical Analysis of the Sea Salt Industry of North-East England', Scottish Geographical Mag., vol. 51,(1935) pp 22-9

25,000 tonnes. While some of this was supplied as a by-product of collieries mainly concerned with the production of household coal much came from shallow mines producing 'pan coal' only. In the seventeenth century such pits existed north of the Tyne, near the North Shields salt pans, but were mainly concentrated above Newcastle bridge, over ten miles away. None were recorded at South Shields. But the cost advantage of mining pan coal locally, avoiding the need for river transport and repeated break-of-bulk, would have been overwhelming. That the close juxtaposition of sea water and cheap coal was the main locational requirement for the sea-salt industry is shown by its growth at Amble, Blyth, Hartley and Cullercoats [1]. So irrespective of the thinness of the seams and the poor quality of the produce, given the existence of coal there, it is possible to predict the likelihood of shallow sixteenth or seventeenth century workings in South Shields. It is one purpose of this thesis to discover how far such predictability extends.

The exploitation of a mineral like coal is one of mankind's more mechanistic activities. The physical variables - depth and nature of seam, geological and hydrological conditions, distance from market - are, by now at least, easily understood. Since constant locational change is inherent in mineral extraction it seems logical that mining should proceed from the point of greatest accessibility and least production cost to the converse of that position. In the past, of course, it never has. Changing technology, incomplete knowledge of conditions underground and the endless variations of human motive and behaviour have precluded so logical a progression. Nevertheless, with the advantage of hindsight and the documentary record of past activity perhaps it is possible to reconstruct the physical and behavioural milieu of the coal industry

1. J.U. NEF, The Rise of the British Coal Industry (1932), vol I, pp 175 - 179.

and then to predict where old mineworkings are.

On 21 March, 1973 at Lofthouse Colliery in West Yorkshire seven miners were drowned by an inundation of water from uncharted mineworkings dating from the 1830s [1]. Such accidents have occurred from time to time throughout the course of mining history. In 1815 an innundation at Heaton Colliery in Northumberland occurred in very similar circumstances and led to the loss of some seventy-five lives [2]. Initially the Lofthouse disaster caused much public concern and, after an inquiry into its causes, an appeal was launched for the collection and collation of old mining records and plans. It is unlikely that such action will ensure against a recurrence of this type of accident since many early documents were lost both before nationalisation, at the dissolution of the coal companies, and because many early mineworkings generated little or no documentation. In the light of such facts as these it becomes a truism to say that too little is known about the past development of Britain's coalfields.

Apart from any practical justifications there is ample reason on purely academic grounds for studying the development of coalfields. Before the age of oil, natural gas or nuclear power incipient expansion of the coal industry was one of the most significant harbingers of industrialisation, perhaps the most common symptom of that stage of economic growth which Rostow called 'the preconditions for take-off'. Coal fuelled the industrial revolution in Britain because, unlike water-power, it had great technological and locational flexibility of utilisation. And yet those changes in the coalmining industry which accompanied coal's vastly

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1. The Times, 22 March, 1973, pp 1-2.
2. M. DUNN, An historical, geological and descriptive view of the coal trade of the north of England (1844), p 23

increased use for manufacturing, for domestic heating and for motive power seem to have been neglected compared to the great importance which historians have traditionally attached to changes in the textile and metal industries, and in transport. The railways and canals developed because of the need to move coal, the textile industries expanded with the use of steam-powered machinery, the metal industries were revolutionised by the use of coking coal in smelting. It is doubtful whether London could have grown to become the world's primate city without cheap supplies of coal from Northumberland and Durham. Could it be that the fundamental nature of its role has led us to take coal for granted?

D. Rowe attributed the notable lack of interest in the coal industry to its generally unattractive aura [1]. Its daunting complexity, its remoteness, until recently, from the main seats of research and the inaccessibility of much of the documentation relating to mining, especially before nationalisation, have also been contributory factors. M. Hughes' study '<u>Lead, land and coal as sources of landlord income in nineteenth century Northumberland</u>' conspicuously, and by its own admission, lacks a convincing treatment of coal while dealing with the other two sources much more effectively [2]. It is an example of the way in which historians, and other scholars too, have fought shy of Britain's greatest industry.

1.1. Previous work

A number of researchers, both in the recent and more distant past, have attempted to throw light on the development of the coal industry in

1. D. ROWE, 'The Economy of the North East in the Nineteenth Century: A Survey', <u>Northern History</u>, VI (1971), pp 117-147
2. M. HUGHES, '<u>Lead, land and coal as sources of landlord income in Northumberland between 1700 and 1850</u>', Durham Ph.D. thesis, 1963.

Britain but the resulting body of literature is patchy and repetitious [1]. The approaches adopted have varied greatly, from the simple chronicling of facts, figures and events favoured by nineteenth century antiquarians to the more flexible explanatory techniques of the modern breed of industrial archaeologists, geographers and historians. A few works are sufficiently fundamental or original to merit special attention here.

J.U. Nef's classic work, <u>The Rise of the British Coal Industry</u>, filled a very large gap but dealt solely with the early formative period up to 1700. His insistence on including some account of all the British coalfields produced a work of prodigious proportions. Nevertheless amid the profusion of detail the basic themes implicit in the early rise of the industry - shortage of fuel, incipient industrialisation, early capitalistic enterprise, new technology - are discernible. Moreover, the dividends to be earned from the skilful use of documentary sources are amply revealed. The work is held together, however, by Nef's instinctive appreciation that coalmining necessarily involves geographical change and by his use of a geographical framework of reference. The opening section deals in detail, and graphically through the use of maps, with the location of early exploitation. And yet even with the historian's limited linguistic tools Nef was able to impart images of the relationship between temporal and geographical change:

> Picture the mouth of the muddy narrow river Tyne, jammed with four or five hundred keels and two or three hundred ships, all

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1. Appendix A is a bibliography containing literature of general relevance to the development of the coal industry before 1850 and also works concerned with the industry in Northumberland. Publications relating specifically to other coalfields have not been included.

> specially constructed for carrying coal; think of the hilly slopes to the north and south covered with hundreds of small carts and waggons leaving behind them trails of black refuse on the green countryside; and then think of the time when the same countryside was at rest except for the occasional movement of some husbandman driving his mule to Newcastle for corn, when the only evidence of the coal industry was a few pits at the water's edge by the hamlet of Gateshead and a few ships whose masters took on a lading of coal to ballast their cargoes of fish, or grindstones, or Jersey cloths. In this comparison you have the contrast between an output of about 40,000 tons and one of about 800,000 tons, and a view of the change wrought around the town of Newcastle in the century following the accession of Elizabeth [1].

With this kind of retrospective mental mapping, Nef colours his work and adds to its lucidity. After forty years, however, the book has attracted a considerable amount of criticism. He was misled by the complexities of coal measurement and some of his numerical estimates have been proved invalid [2]. There are a number of mistakes of detail [3] and the tone of his argument - basically that the pace of industrial and technological change accelerated rapidly between Elizabeth's accession and the Civil War - now seems rather laboured. Nevertheless Nef's enormous contribution, especially in the context of what had gone before, should not be underestimated.

Inviting comparison with Nef is <u>The Coal Industry of the Eighteenth Century</u> (1929) by T.S. Ashton and J. Sykes which appeared at about the same time. The book bears the mark of the more conventional analysis

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1. J.U. NEF, op. cit., vol I, pp 28-29.
2. R.A. MOTT, 'The London and Newcastle chaldrons for measuring coal', <u>Archaeologia Aeliana</u>, 4th series, vol XL, (1962), pp 227-239
3. See pp 64, 72

of the economic historian in which there is little reference to spatial change. In fact where the book suffers most in comparison with Nef is in the complete lack of a geographical framework of reference. It contains no map and yet place-names are numerous. Admittedly the main themes which the authors follow are essentially chronological; the progress of technology, changing conditions of employment, variations in trade and supply. The work is therefore historical and thematic. As such it betrays the historian's weakness for the unusual and the idiosyncratic. Without accounting for the immense inter and intra-regional variations in mining activity it is very difficult to mould the range and volume of detail into clear viewpoints and generalisations. In many ways Ashton and Sykes' book does not measure up to the scope of the task. Nef spent two volumes coming to terms with the industry in its infancy. Ashton and Sykes in one volume merely glimpsed the enormously more complex industry of the eighteenth century.

These are perhaps the two most important general works on the early development of the British coal industry yet produced by professional historians. More recent work may soon assume similar stature but only time and usage can really assign or deny importance [1]. Much of the substance of work done by historians in the twentieth century, however, rests on the efforts of earlier amateur writers and antiquarians. Some of their works merit attention here.

An anonymous writer with the initials J.C. wrote a pamphlet entitled The Compleat Collier (1708) in the first decade of the eighteenth century and this is probably still the best description of mining technique in

1. B.F. DUCKHAM'S History of the Scottish Coal Industry (1970), for instance, seems methodologically more advanced than both Nef and Ashton & Sykes.

the north of England before the age of steam-power. During the ensuing two centuries a number of more detailed studies of the coal industry appeared. William Fordyce's History of Coal and Iron (1860) provides a record of the technological state of the industry in the mid-nineteenth century as well as a series of superb lithographic sketches of colliery and industrial scenery by T.H. Hair. An Historical, Geological and Descriptive View of the Coal Trade of the North of England by Matthias Dunn, the accomplished Tyneside viewer, gives an outline of the progress of the industry by 1844 and a useful summary of technological developments. W.S. Jevons' The Coal Question (1865), reflecting the recurring fear of fuel exhaustion, made a considerable impact in its day and, as a piece of academic writing, is still worthy of close examination. His son, H.S. Jevons, wrote The British Coal Trade (1915), which is a superb examination of the industry at its zenith immediately before World War I. More recently still Professor Granville Poole edited An Historical Review of Coalmining for the Mining Association of Great Britain in 1924 and this provides a rather more systematic consideration of historical trends.

Among the nineteenth century histories of the coal industry, however, the works of Robert L. Galloway deserve special attention. His History of Coal Mining in Great Britain (1892) anticipates Ashton and Sykes. More useful to the student of the industry are the Annals of Coal Mining and the Coal Trade (1898) and (1904). Baron F. Duckham points out that

> An astonishing fact about the annals is that it was compiled almost exclusively from sources in print. At the date when Galloway wrote the vast riches of county record offices with their collections of family papers, often so relevant to mining history, scarcely existed. Coal-owners and colliery proprietors were then both equally unlikely to allow access to their archives, while for the amateur historian (which is after all what Galloway

> was) working far outside London, the difficulties in the way of making full use of either the British Museum or the Public Record Office were well nigh insuperable [1]

The annals provide essential background for any study of the coal industry.

Until recently the contribution of geography to the understanding of the development of coalfields had not been particularly auspicious. In the past five years or so, however, coalfield studies in both geography and history have achieved something of a take-off. Basic descriptions of spatial change have usually appeared in the systematic regional texts, are essentially descriptive and derive in the main from secondary sources and maps. A.E. Smailes has offered a number of articles concerned with the northern coalfields from which the industrial chapters of his book <u>North England</u> (1960) are mainly derived. Using simple techniques Smailes provides a generalised picture of the wider areal changes inherent in the development of the Northumberland and Durham coalfield. Figure 1 is a reproduction of his synoptic map of the coalfield. It can claim to represent the extent of existing knowledge of the spatial development of the Great Northern Coalfield.

More detailed explanation of areal changes in coalmining has mostly been left to industrial archaeologists and local historians. The growth of industrial archaeology as a field of interest in the past decade or so has highlighted the need for a more systematic examination of the evolution of coalfields. A number of valuable studies have already emerged. Baron F. Duckham's <u>A History of the Scottish Coal Industry</u> may be

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1. R.L. GALLOWAY, <u>Annals of Coal Mining and the Coal Trade</u>, (1971). Duckham's introduction to the David and Charles reprint.

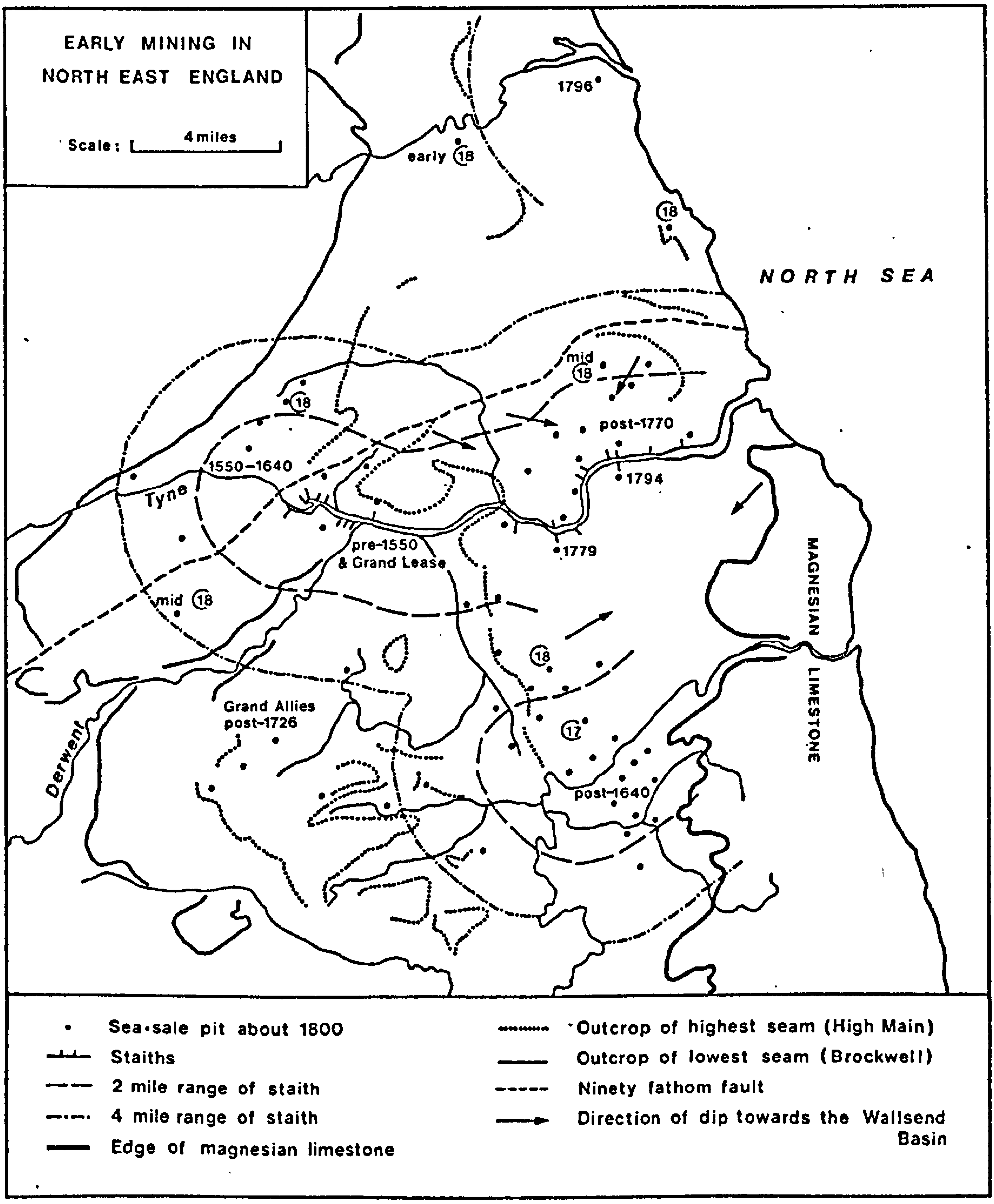

Figure 1 : Smailes' map of the Great Northern Coalfield

regarded as a prototype for more intensive regional studies of coalfield development. J. Langton's work on the Lancashire coalfield is also symptomatic of the trend towards more detailed examination of the changes occurring within coalfields [1]. Accepting the proposition that each British coalfield is worthy of the depth of analysis which Duckham has applied to Scotland there still remains an enormous amount of research to be done on other coalfields. It is hoped that this thesis makes a contribution to the task.

1.2 Sources

> Many particulars relative to its (Newcastle's) commerce I tried to get, but in vain ... This town is supposed to contain 40,000 souls, and to employ of its own, 500 sail of ships, 400 of which are colliers ... These particulars will by no means satisfy you - they are far from satisfying myself, but they are all I could procure ...
>
> Arthur Young (1770)

All historical research is limited by the availability and reliability of data. The problem of source material is universal over the whole historical spectrum and each subject area, each timescale is characterised by degrees of abundance or dearth. With regard to the primary record of past economic activity the chief feature is often the lack of easily interpreted and relevant data which places strict limitations on the conclusiveness and type of explanation. Some problems and gaps can be overcome by prediction and extrapolation but with decreasing availability and quality of data research productivity falls off rapidly.

The relevance of any study must be measured by the additional contribution

1. J. LANGTON, 'Coal output in South-West Lancashire, 1590-1799' Economic History Review, XXV (1972), pp 28-54

it makes to existing resources of understanding, the solution of outstanding problems, the infilling of gaps in contemporary knowledge. When an area of ignorance has been identified and delimited the first basic research questions should begin to present themselves. The process of elaboration is thus initiated and proceeds along simple question-and-answer, challenge-and-response lines until the point of fullest explanation has been achieved. In historical research the ability to answer research questions depends largely on the quality and relevance of the data. The quality of the data may be measured in terms of the ease with which it can be adapted to explanatory techniques. The relevance of data varies according to its potential contribution to the solving of basic research problems.

Fortunately lack of documentary material is not really a problem for the student of the Northumberland coal industry between 1600 and 1850. But variability in quality and relevance does create difficulties. In addition there is one period, extending from about the mid-seventeenth century to 1720, where documentary evidence is relatively sparse. However, this is mainly due to the lack of actual activity during a period when most coal was coming from Durham pits. This points to a general problem with coalmining history; whether the sudden ending of a sequence of documents signifies the cessation of operations or the subsequent loss or misplacement of material.

This work is largely based on material reposited in the North of England Institute of Mining and Mechanical Engineers, the Northumberland County Record Office, and the Public Record Office. In addition, documents and literature from the Newcastle Central Library, Gateshead Public Library, Birmingham Reference Library, Alnwick Castle, the British Museum and the Newcastle Literary and Philosophical Society Library have made minor contributions. The records in the strong room of the mining institute have been the most important source. It is no exaggeration to say that these papers represent some of the most important sources for the detailed reconstruction of early coalmining that remain in existence. In fact, they were deemed so important that during World War II, to avoid the risk of bombing, they were removed from their fire-proof strong room and kept down a coalmine! Their value is heightened by the fact that they relate to the coalfield which was, until the late nineteenth century, the most technically advanced in the world. Since these sources are so fundamental it is worth describing their nature in some detail.

Most of the papers in the mining institute derive from the activities of mining engineers and agents or, as they styled themselves, the viewers. These were a remarkable class of technicians who appeared as early as the sixteenth century and had the responsibility of general colliery management and the planning of new winnings. More will be said of them later [1]. It is symptomatic of the lack of attention which coalmining history has received in the past that these men, who contributed enormously to British industrialisation, should have remained so obscure.

The documents themselves are extremely heterogeneous. They range from maps and plans of colliery workings to estimates of cost for new materials and machinery to accounts of output to 'lining books', which describe the nature and extent of underground workings in the minutest detail. Unfortunately there is little standardisation and the type of information which has survived for one colliery cannot necessarily be matched with the record of another. This lack of comparability in the documentation of individual collieries is a serious drawback. The Watson Bound Papers;

1. See pp 230-5

for instance, contain a substantial body of data on almost every colliery in Northumberland which was active between 1760 and 1820. Yet it is impossible to derive for each even basic information like yearly output. Some have yearly, even weekly, production presented in perfect detail. Others reveal only the most hazy indications of level of output. This is extremely perplexing since it precludes any simple reconstruction of changing spatial patterns on a regional scale.

Two points help to explain the diversity of the data. Firstly, there were no standard accounting or book-keeping procedures for collieries at this time. There was no legal requirement to keep records. They merely kept what accounts were necessary for payment of rents, profits and debts, and also those papers and plans which would be relevant to the future planning of the concern. Since the size, structure, location, ownership and management of individual collieries varied greatly the documentation which they have generated shows great heterogeneity. Secondly, most of the documents in the mining institute represent the personal collections of mining viewers like John Watson or John Buddle. These men probably preserved only those papers which they themselves considered important and disposed of other material as trivia.

In spite of this, however, when all the material for an individual colliery is collected, arranged chronologically, examined systematically and interpreted logically, it is often possible to piece together a clear picture of the life-cycle of the concern from inception to fruition to demise. There is a certain type of document which crops up repeatedly and is especially useful for this purpose. From time to time during the development of a colliery the opinions of the most eminent viewers of the day would be sought by the owners as to the condition of the concern and the method by which future working should be pursued. The viewers, perhaps five or six of them working as a team, would produce a written report or view to be sent to the owners. These reports have survived in considerable numbers and have proved invaluable in the construction of the individual colliery histories which collectively have provided the foundation for this thesis.

The shortage of high quality data (for instance, lists of collieries, giving precise numerical information about output, employment, machinery, etc., maps of the whole coalfield showing location and depth of pits and the structure of land and mineral ownership) does not extend over the whole timescale. The first half of the nineteenth century is well-endowed with high quality documentary and cartographic material. In fact, the use of this retrospectively has facilitated a much clearer understanding of the whole developmental process. There are probably two reasons for the increase in documentation towards the end of the eighteenth century. Firstly, by then a greater degree of internal control was exercised by the Committee of Coal Owners of Tyne and Wear in order to regulate output, limit competition between collieries and prevent over-supply of the markets. Such restrictive practices needed organisation and organisation generated documentation. Secondly, certain viewers, like John Buddle, Matthias Dunn, William Brown and John Watson, had achieved such a standing as consultants on all colliery matters that they had a detailed understanding of the condition of the whole coalfield and were not merely concerned with individual collieries, as earlier viewers tended to be. The Buddle collection has a number of extremely detailed synopses of all the Tyneside collieries. These represent data of the highest quality. Unfortunately for the seventeenth century there is no material to compare with this. For this period it has been necessary to adopt a more oblique approach, using leases, family papers, legal and manorial sources. Consequently most of the seventeenth century sources used have come from repositories other than the mining institute, notably the Public Record Office (exchequer and chancery papers, port books, etc.) and the Northumberland County Record Office (Ridley and Delaval papers, Bell Collection maps, parish registers, etc.). A list of the main sources in the mining institute which have been used is given as Appendix B.

A number of problems related to source material and inherent in the study of mining history have been encountered and are worth mentioning. Certain interpretative problems arise partly from the distinctive dialect of the Northumbrian mining community and partly from the technical nature of mining operations. The linguistic development of the dialect of north-east England has been profoundly affected by the involvement of its population in coalmining. Words survive today in vernacular use which were originally and literally applied underground in a technical sense to processes and objects which, with the inexorable progress of technology, have passed into obscurity. Not surprisingly many words and phrases which are identifiably Northumbrian crop up in the documents. One example to show the complexity of technical terminology may be cited here and is taken from John Watson's view of Plessey Colliery on the 25th September 1749:

> The Lark Pit ... has a small feeder of water rises out of the thill ... they have met with a dyke in their West Main Gate about 120 yards from the shaft which is an upcast of about 4 yards to the west & they have set up the Mother Gate and drifted about 20 yards west and has met another rise hitch of about 2 feet. They have set in a So. Headways at 25 yards west from the shaft and has won eleven winnings and has about 90 yards further south of whole coal to win yet ... the coal

bleeds very sore above the dyke ...[1]

Fortunately, G.C. Greenwell's A Glossary of Terms used in the Coal Trade of Northumberland and Durham (1888) has been invaluable in surmounting problems of technical interpretation.

A further difficulty, however, relates to the variety of ways in which coal was measured. The peck, ten, boll, fother, score, corf, waggonload, wainload, keel, chaldron and ton were all used to measure quantities of coal during the period under discussion. What is more confusing is that the actual size of some of the units also changed through time so that their relationships to other units varied. For example, a ten of 220, 330, 420, 440, 520 and 550 bolls was used on Tyneside between 1600 and 1850. Moreover, new measurements were not adopted universally at the same moment in time [2]. R.A. Mott has shown how changes in the size of the chaldron were responsible for misleading Nef in some of his estimates of production [3]. All this greatly limits the confidence with which quantitative assessments and comparisons can be made.

1.3 The spatial and temporal scope

The study area comprises that part of Northumberland between the rivers Tyne and Blyth and extending from the edge of the commercially exploited coalfield (represented by the most westerly outcrop of the Brockwell Seam) to the North Sea coast. Figure 2 shows the extent of the area within the whole coalfield of Durham and Northumberland. But for a variety of reasons (which will become increasingly clear) surface boundaries are unsatisfactory for studying the geography of mining operations.

1. NEIMME, Watson Collection, 8/4, pp 49-50
2. M.J.T. LEWIS, Early Wooden Railways, (1970), pp 184 - 189.
3. R.A. MOTT, op. cit., pp 234-5

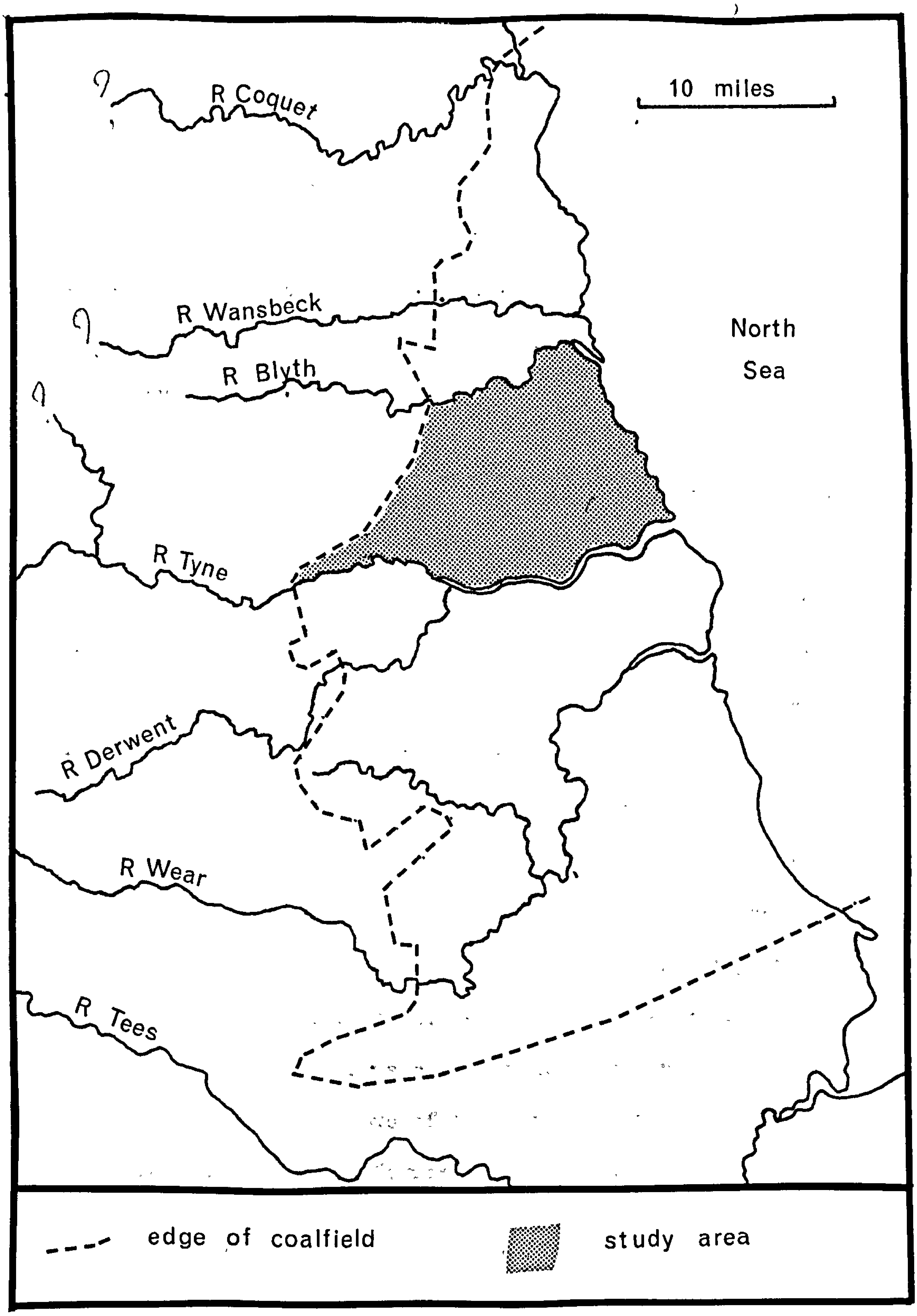

Figure 2 : The extent of the study area

The boundaries adopted here are convenient in a number of respects but their shortcomings should be borne in mind. The western boundary, the outcrop of the Brockwell Seam, is suitable since it represents a clear discontinuity in the coalmining landscape. The coastline is less satisfactory, however, since subterranean mining operations can extend under the sea, although this occurred very infrequently in the period before 1850. On the other hand such operations must be dependent on pitheads and surface operations on land and therefore within the study area. The use of rivers as boundaries is less satisfactory still even when, as with the Tyne they represent an important administrative boundary. Mining extended beneath even large rivers like the Tyne from a relatively early date. But since the earliest technology made use of free drainage penetrations below river beds were probably infrequent and workings below sea-level even rarer. In the seventeenth century most coal was obtained from valley sides. With the advent of steam-pumping and deeper workings from about 1725 surface relief exerted a lesser influence, although it was important in the location of pits even in the nineteenth century [1]. Even when, as was normally the case, rivers represented the boundaries of royalties mining often extended across the demarcation where collieries worked adjacent royalties 'by outstroke'. Consequently, it is possible that, by using surface features to delimit a study area, mining operations originating from parent collieries outside may be included while some of the workings of collieries within the study area may be excluded. Figure 3 summarises some of these difficulties.

Clearly mining boundaries present a problem for the geographer. One possible solution might be to adopt subterranean boundaries conforming to the limits of workings of individual collieries. Besides involving

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1. See Figure 37

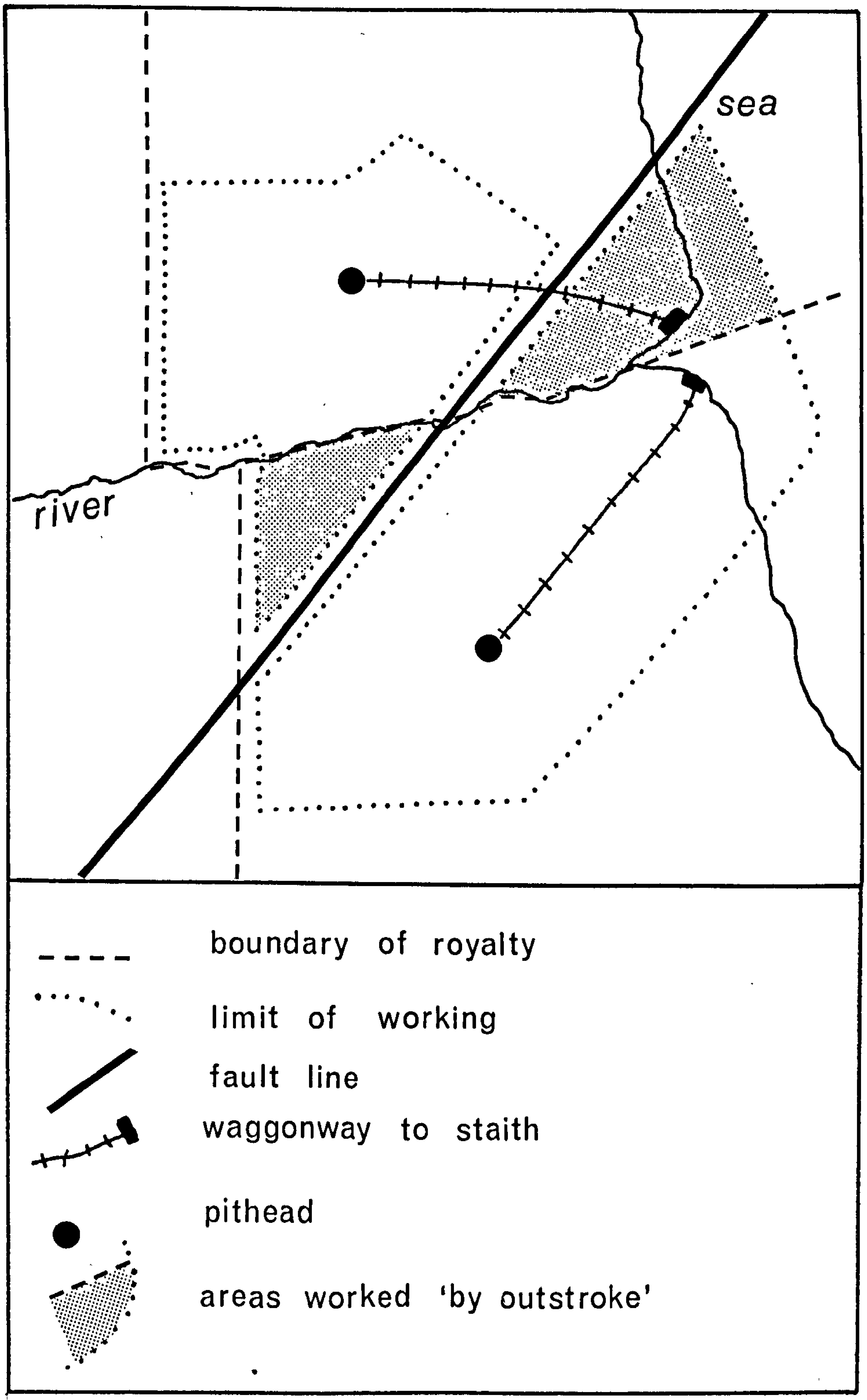

Figure 3 : The hypothetical development of working from two collieries, illustrating the difficulties in delimiting coalmining areas

complex and difficult demarcation such boundaries would have little meaning. Obviously it is the nature of coalmining that the underground limits of working were in a constant state of flux. Furthermore the ambit of drainage and ventilation operations did not necessarily match the extent of workings. The pumping operations of one colliery sometimes drained part of another. On the whole the most convenient compromise seems to be the adoption of surface boundaries which represent clear geographical discontinuities, are easily comprehensible and also have a bearing on the pattern of mining operations.

It should be noted, however, that the study area now delimited has a further disadvantage in that it divides in half the Tyne Valley which, in many respects, represents a discre~~et~~te geographical unit. In the period before 1800 the rivers Tyne, Wear and Blyth were clear foci of the coal trade since all collieries (with the exception of those few with coastal shipping facilities) needed to lead their coal to staiths along the river banks for transfer to keels or colliers. The importance of gravity assistance in waggonway transport which militated against the movement of coal across interfluves added further to the clear separation of the river valleys, the pattern of waggonways having a peculiar dendritic relationship with the navigable channels. This was further reinforced by organisational distinction. During the seventeenth and eighteenth centuries the coal magnates of the Tyne Valley were distinct from those who shipped from the Wear. Although this distinction was never complete, and tended to blur with time as the pattern of colliery ownership and shareholding became more complex, it endured for most of the period here under consideration. Clearly there are strong arguments favouring the treatment of the Tyne Valley as a single unit.

On the other hand the area of Tyne coal catchment was not stable.

Sometimes collieries within the ambit of Tyneside trans-shipment at one time would adopt alternative shipping facilities elsewhere at a later date, or vice versa. This certainly occurred in the Seaton Valley area of Northumberland. Here during the eighteenth century the nearest navigable water inevitably provided the site for a staith. By the nineteenth century, however, the iron railway and technological changes in coal shipping had necessitated links with the Tyne. Consequently collieries in the Cramlington and Hartley districts which had shipped their coal from the river Blyth or from the coast in the seventeenth and eighteenth centuries used Tyneside staiths in the nineteenth.

Evidently no areal unit is ideal for tackling questions concerning the geographical development of coalmining. The compromise adopted here has the advantage of an area of sub-regional proportions, sufficiently small to allow detailed analysis and large enough for wider implications to become clear [1]. In addition this particular area is almost unique in the intensity and variety of its experience of coalmining before 1850.

Time, which is the substance of history, can be broken up into segments convenient for analysis in much the same way as the geographer divides space, which is the substance of geography, into regions. The choice of an appropriate timescale for this particular study was not entirely straightforward. The development of coalmining in the north-east of England has been a process continuing up to the present time from a beginning the date and nature of which have been lost in the inadequately chronicled mist of the early middle ages. But the chronological

1. At the time this work was undertaken other historical geographers were researching developments in North Durham and, in order to spread the mutual research effort as evenly as possible, it was agreed that this study should concentrate on Northumberland.

development of coalmining has not taken place with equal or consistent intensity. Generally it has occurred with increasing momentum but the curve of acceleration has not been smooth. However, it is difficult to measure the development process. Figure 24, p196 showing the growth of coal shipments from the Tyne may, at first glance, be taken as a reasonable indicator of the pace of development. But is is likely that the expansion of output during a period of growth is based on the technological progress and planning of a previous period. In other words output alone does not reflect precisely the totality of development in which technological and institutional change are as important as, and indeed vital to, continuing and increasing production. Since it has stronger geographical implications, however, this thesis is primarily concerned with the changing pattern of coal exploitation.

Traditionally the historian uses critical points in time as limits to confine the width of his investigation. The delimitation of such temporal boundaries often presents no difficulties. In a biographical study, for instance, the birth and death of the subject provide the obvious chronological starting and finishing points. In the study of economic development, however, the problem of adopting temporal limits is more difficult. The date of critical changes is often hard to fix. For example, in the development of the coal industry the change from animate to inanimate power for drainage and haulage purposes was fundamental in the movement from small to large scale operations. It might be seen as a useful watershed from which to begin a study such as this. But no date can be assigned to this change with any certainty and even accepting a wide margin of error. The adoption of water power for drainage purposes began sometime in the mid-seventeenth century. But it spread very slowly, affecting some collieries but not others, and was still less efficient than horsepower in some situations a century later. As far as the mechanisation of haulage is concerned, it began with the replacement of the whim gin by the water wheel from the middle of the eighteenth century; and yet despite the arrival of steam power, electricity and the internal combustion engine, pit ponies were still in use in Northumberland in the mid-twentieth century. Clearly the great divides in technological progress, insofar as they affect economic development, are difficult to date precisely.

It is equally difficult to date and evaluate organisational changes. The transfer of coal-bearing property from ecclesiastical and episcopal ownership into the hands of the gentry and the lay aristocracy in the sixteenth century, the importance of which was emphasised by Nef [1], is a case in point. It was absolutely fundamental to the later expansion in output but it is difficult to attach a date to it.

A compromise solution has much to offer and by choosing a lengthy period of two and a half centuries and by using round dates the danger of attaching too much importance to temporal boundaries is avoided while the approximate extent of the study is well indicated. The period from 1600 to 1850 covers a great phase of coalmining development from the eve of its primary expansion up to the middle of the nineteenth century when a technologically and organisationally sophisticated industry had emerged from the first stages of socio-economic revolution. The beginning of the seventeenth century has advantages other than simplicity. The two great changes which Nef regarded as essential for the expansion of coalmining on Tyneside - the transfer of coal-bearing property already mentioned and the exhaustion of London's supplies of woodfuel - had, in the former case, already transpired and was, in the latter, by then occurring. Furthermore some valuable documentation enables us to determine with some

1. J.U. NEF, op. cit., vol I, pp 133-145.

accuracy the size and nature of the coalmining industry in the first few decades of the seventeenth century. At the same time the middle of the nineteenth century as the terminal date gives the period the symmetry of a quarter millenium and takes us through the century of industrial revolution up to the eve of Northumberland's greatest phase of economic expansion, when coalmining began to be challenged in importance by the growth of secondary industries which, in many ways, had themselves been engendered by coal.

Thus a framework in space and time emerges within which an investigation of the processes of growth and change can take place and which, although not self-contained in any way, can serve as a suitable vehicle wherein the main elements of concern can be co-ordinated. The title which stipulates 'Northumberland' does not suggest so narrow a region as has been defined here. However, the study area comprises the part of the county where the most technologically advanced and intensive coalmining before 1850 took place. Most of the collieries in Northumberland outside this area were small 'landsale' pits catering for local consumption only. The only exception to this is the coalfield of north Northumberland where there were some larger collieries which shipped coal from Berwick on Tweed but these were geographically remote and separate from the main coalfield.

1.4 Methodology : The hypothetical approach

> With each step back in time history becomes more geographical until, in the beginning, it is all geographical.

Yet in his introduction to A History of the Scottish Coal Industry Baron F. Duckham observes:

> It is no purpose of this book ... to trace the historical geography of Scottish coal mining. Our concern is with industrial history within the framework of the given data of geology and of man's elemental response to it. The validity of the geographical approach is recognised, but it is the historian's task, very broadly defined, to begin where the geographer leaves off; to examine the economic, social and political institutions that emerge rather than to analyse the importance of one series of data which, fundamental as it may be, remains the stage and scenery, not the play.

He adds a rather censorious footnote to this statement;

> Adherents to historical geography necessarily make wider claims for their subject - which may be one reason why so many of them write a kind of social and economic history.

This statement underlines the historian's longstanding failure to understand the nature of geography as spatial and locational analysis. For this the geographer may be partly to blame since his frequent and often unqualified excursions outside the core area of geography, although innocent and sometimes useful in themselves, inevitably lead to a misunderstanding of his motives by other disciplines. Of course to suggest that historical geography is "a kind of social and economic history" is no more a condemnation of the subject than it is of bio-chemistry to say that it is a kind of biology. Nevertheless it broaches the question of whether the geographer has any special contribution to make to the study of the coal industry and, if so, what is the nature of that contribution.

The historian's approach to social and economic problems is characteristically wide and all-embracing even within fairly narrow thematic confines. He has no single or solid index by which to gauge the pace and nature of change. This is hinted at in Duckham's statement when he says "... the historian's task, very broadly defined". It is possible that too often the historian's task is too broadly defined. The result is a loss of direction and clarity with unrelated explanation, the simple placing of events within a matrix of time. On the other hand the geographer always has an easily comprehensible basis upon which to build his explanation, a point of reference by which to steer; that is the landscape, the spatial arrangement of phenomena at any given point in time. With the process of economic development the changing location and spatial intensity of production is an excellent point of reference from which explanation can begin. Without such a foundation historical explanation tends to take place within a vacuum and, as a result, history is less tangible. Generally speaking the historian is in his element when analysing the way in which relationships among human beings and human institutions have changed but is less equipped than the geographer for dealing with the varying response of man to his environment in which spatial and temporal relations are closely interrelated. The additional lucidity which can be achieved in historical explanation when the landscape is used as a basic index is amply displayed in the recent History of the English Landscape series.

M.G.A. Wilson's study of the New South Wales coalfield may be cited as a good example of the way in which geographical method can contribute to the understanding of coalfield development. The major studies of the location of economic activities have little to say about extractive industry although agriculture and manufacturing have received much attention. This is mainly because mining is so obviously and necessarily resource-orientated. It does not adapt well to theories in which material weight-loss or market area are principal criteria. Edgar M. Hoover observed that

> We need not enquire whether production will take place at the source of the material or at the market or somewhere else, as we must for manufacturing. That question is settled for us. Extractive industries are by definition located at the source of their material; their location involves merely a choice among various possible sources ... the lowest combination of cost-plus freight determines from which source any consumption point will be served [1]

True, it was this last influence which caused the rise of the Great Northern Coalfield in the first place, the consumption point being London. But this does not explain variations in the pattern of production within the confines of the coalfield. In the development of any coalfield some areas expand production while others decline and others remain as yet unexploited. To say that 'cost-plus freight' determines this pattern in all its intricacy is too much a generalisation. The possible patterns of exploitation are infinite and the variations in the locational factors very complex. This was appreciated by August Losch:

> The location of any particular coalmine ... cannot be fully explained by the presence of coal. Only the whole relationship between production and demand that results in profits will make clear why coal is mined at just this spot and at no others. Which of the possible mines will actually be worked depends among other things on its technical productivity and the local prices of the factors of production on the one hand (cost curve) and transport relations to the market (demand curve) on the other [2]

In attempting to advance these ideas further M.G.A. Wilson developed

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1. E.M. HOOVER, 'Location Theory and the Shoe and Leather Industries', Harvard Economic Studies, LV (1937), pp 7-8
2. A. LOSCH, The Economics of Location (1954), pp 35n, 43

a simple model based on "... the changing distribution of mines associated with the progressive development of a field over a period of time". He then sought to test the applicability of the model against the historical development of the New South Wales Coalfields, thereby adopting a classic approach in geographical methodology. Wilson's model is reproduced as Figure 4. It was based on the following tenets:

> ... production costs on any coalfield will tend to vary according, inter alia, to depth, distance from the outcrop, the seam characteristics, whereas freight charges will, to some extent at least, be affected by the length of on-field haulage; for example from pit head or tunnel mouth to shipping point. It is not unreasonable therefore to expect that individual entrepreneurs will attempt to locate mine holdings on a field so as to minimise these combined charges [1]

Wilson's model illuminates the way in which the interplay of overland haulage and seam exhaustion (which find expression themselves through the continual need for cost minimisation in order to remain competitive) may affect the movement of mining operations. It is a simple but effective model. Its aim - "to show that the spread of mining on the main coalfields of New South Wales has followed an orderly pattern consistent with the continuing search for a least cost location" - is only partly fulfilled as Wilson himself admits in conclusion:

> On the three coalfields examined it is clear that the changing pattern of first workings has in fact involved, on those fields with suitable physical conditions, the periodic substitution of production costs for transport charges and vice versa, and in

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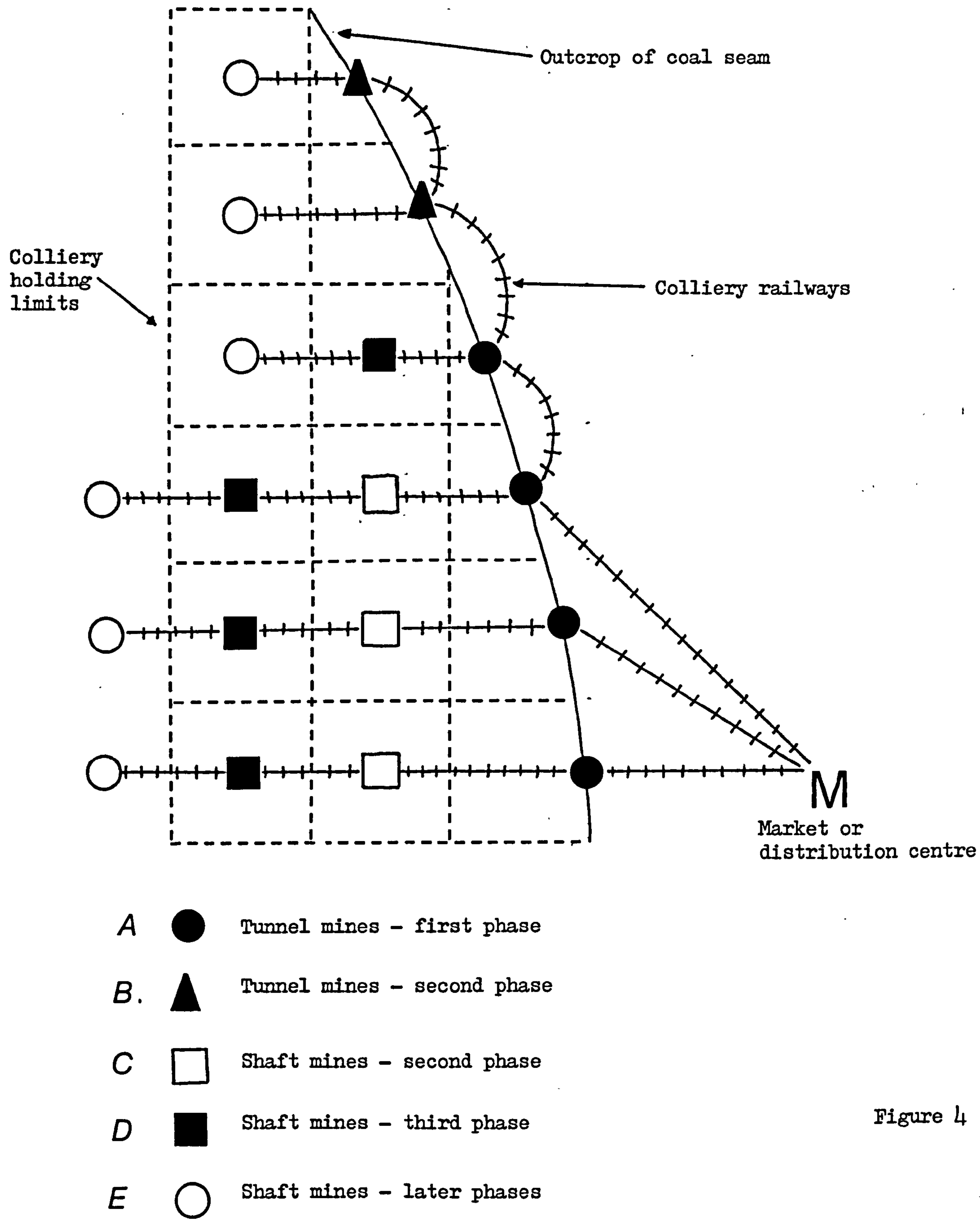
1. M.G.A. WILSON, 'Changing Patterns of Pit Location on the New South Wales Coalfield', <u>Annals of the Assoc. of American Geographers</u>, vol 58 (1968), p 78



A : Production tends to increase with distance from the outcrop. First mines would be tunnels into the outcrop relatively near to the market.

B : In course of time, increasing demand, the exhaustion of the early worked coal and growing underground haulage distances would necessitate the opening of additional collieries.

C : Eventually as the outcrop workings closest to the shipping facilities were exhausted and haulage distances became greater, costs could be reduced by sinking shaft mines near to the shipping place.

D and E : As the upper seams of these mines became exhausted and extraction costs increased shaft mines would be opened further afield.

Figure 4 : Stages in the development of a hypothetical coalfield, showing the progressive movement away from the outcrop and the periodic substitution of working for transport costs (after M.G.A. Wilson).

> the other, development away from those areas offering maximum accessibility. The link between these effects and the postulated cause, i.e. a deliberate attempt to minimise total delivered costs, is less clearly demonstrated, however, although there is some supporting evidence relating to both production and transport components on the South Maitland field [1]

In the context of the Northumberland coalfield, transport and production costs undoubtedly exercised a pervasive and general influence. But the changing pattern of mining operations was much more complex than is suggested by Wilson's model. Three factors in particular contribute to the complexity; physical and geological conditions, changing technology and the ownership of coal and land. The combination of these variables produced an intricately complicated locational pattern and one which does not accord noticeably with Wilson's idealised pattern. But he did add the proviso to his basic tenets that "... the range of possible locations might be expected to vary from time to time under the impact of changing technology and the exhaustion of working seams". Fortunately for him, in the New South Wales Coalfields, which were developed fairly late when coal-mining and -moving techniques were already highly developed, technological change played a lesser role in causing spatial variations in mining. In the development of the British coalfields, however, the effects of changing technology have been profound. In Northumberland for instance, it frequently occurred that mining activity, especially after a technological advance had extended the depth from which coal could be extracted, returned with renewed vigour to localities which had been abandoned earlier. There was no simple spread of coal-cutting. Wilson's model accounts for only one seam. But mining frequently returns to the same surface location when

1. M.G.A. WILSON, op. cit., p 89

lower seams become economical to work, either because of new extraction technology or because the wider exhaustion of upper seams raises the price of coal. A vertical cross-section through a hypothetical coalfield helps to illustrate this point and Figure 5 shows how operations may recommence at the same surface location after earlier abandonment. In Northumberland and Durham, it is true, there was a general movement of the theatre of mining operations away from the coal most easily accessible to the market (generally that nearest to navigable water) and yet there were still large and active collieries on the banks of the river Tyne in the mid-1960s (the Rising Sun Colliery, Wallsend, for example), perhaps five hundred years after mining had begun there.

Obviously it is misleading, even in general terms, to interpret the spatial development of coalmining as a centrifugal spread of pits on the surface of the earth with new and remoter pits opening in the wake of coal exhaustion or as a result of market expansion. The weakness of Wilson's model, and also of the geographer's approach in general, is that it attempts to portray in two dimensions a process which occurs in three dimensions. But models are made to be criticised and adapted and this one provides a useful starting point from which to begin a detailed investigation of the spatial development of a coalfield.

1.5 Methodology: The behavioural approach

> Perhaps the most important advance that has been made in historical geography in recent years has been a new view of the past as seen through the eyes of contemporary observers and a critical examination of the evaluations they made of the objects they observed. In effect, we are beginning to chart some of the perceptual surfaces of the past and to

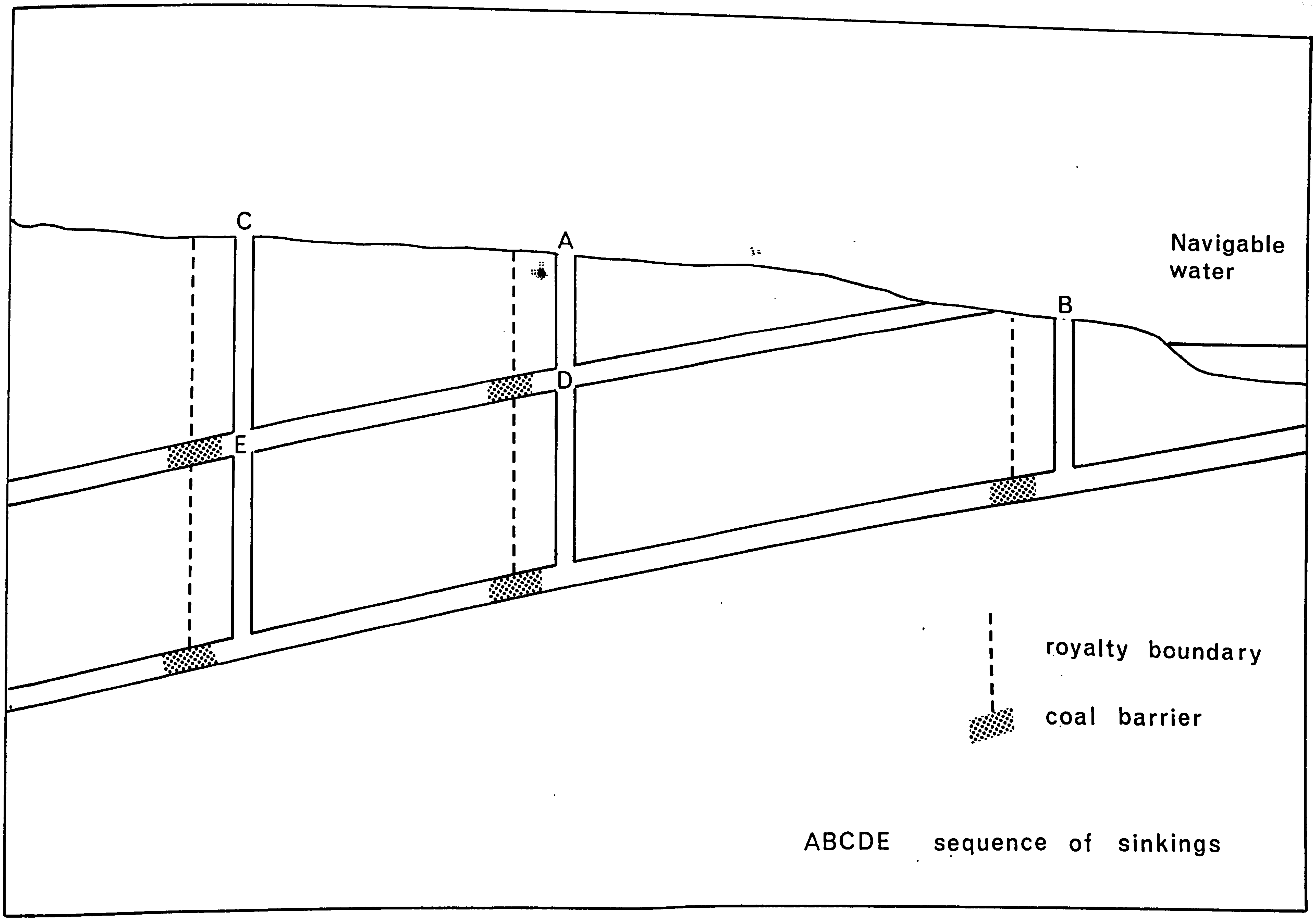


Figure 5 : A hypothetical sequence of winnings, with two seams, where depth is the main cost determinant

discover behavioural environments that differ from our own [1]

The exploitation of coal does not occur as a perfect response to physical reality. It develops within the constraint of man's perception of reality. Even if it were possible to devise a mechanistic model of mining development perfectly tuned to the realities of physical and market conditions it is highly unlikely that the progress of mining would occur in precise conformity with it. Human behaviour can never be completely rational since motives vary from person to person and through time. Moreover the dynamism and variability of many locational factors, like transport facilities, material supplies and markets, preclude location even without the influence of personal preference or prejudice. The rate of technological change, which largely determines the degree of locational inertia, is itself closely connected with human whim and, in consequence, is difficult to build into predictive models.

This goes far towards explaining the current disenchantment with theoretical models of industrial location. Recent empirical studies have relied heavily on the interview-survey method for the investigation of locational decision-making. By such an approach a large variety of factors influencing the location of industrial activity - transport facilities, cost of property, labour climate, proximity to market, material supplies, to name a few - can be analysed with some degree of objectivity. This method is not possible in historical studies so that the documentary evidence must be peculiarly suited to revealing the decision-making processes of past times.

1. H.C. PRINCE, 'Real, imagined and abstract worlds of the past', in Progress in Geography, vol 3 (1971), p.24

There is a considerable amount of documentation, especially in the form of colliery views, leases and correspondence, which gives a good indication of the behaviour of those coal-viewers who were responsible for many of the key decisions taken with regard to the coal industry in Northumberland before 1850. Their decision-making activities form the underpinning upon which much of the substance of this thesis has been built. Although they were not the only elements in the decision-making process (lessees, landowners, and even overmen were sometimes important) it was unusual for their advice to go unsought or unheeded. The need for key decisions arose at different stages during the development of a colliery and the whole process has been expressed simply as Figure 6.

A.R.H. Baker recognised the shortcomings of the theoretical approach and recommended that it be augmented with small-scale behavioural analysis:

> The widespread dissatisfaction with existing geographical theories may be due to a preoccupation with spatial patterns and a neglect of small-scale generating processes ... a closer specification of narrower social contexts is likely to be a more fruitful line of advance than a search for sweeping generalisations [1].

Later he expands this theme:

> The possibilities ... for analysing the decision-making process in historic time should not be underestimated. Focusing attention on the decision-making unit rather than on aggregate geographical patterns will involve examining more closely than hitherto the records of individual units, such as families, farms and firms. It will involve looking afresh at historical sources traditionally used by geographers as well as investigating

1. A.R.H. BAKER, Progress in Historical Geography (1972) pp 24-28

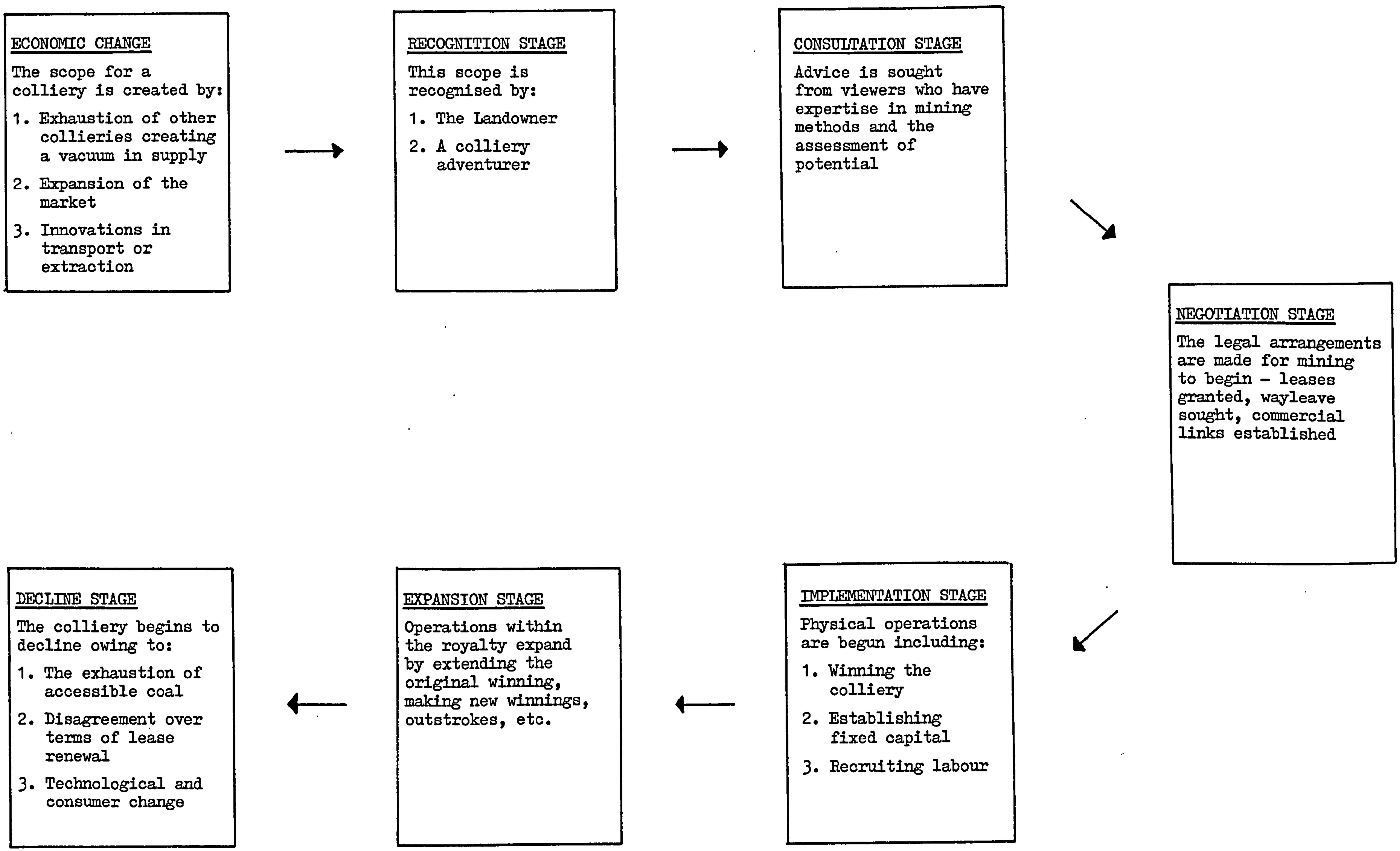


Figure 6 : The decision-making stages in colliery development

new sources. Even descriptive accounts and diaries can be analysed systematically [1].

The approach suggested here is adopted for this study but the individual units are not families, farms or firms but collieries.

Environmental perception, however, does not provide any mystical new solution to problems of historical and geographical interpretation. Since evaluations of behaviour in the past are tainted by the attitudes of the evaluers an entirely objective approach is impossible. "The past is necessarily reappraised in the framework of present thinking conditioned by present needs and present problems" [2]. Nevertheless, it is hoped that the effects of human attitudes and behaviour on the location and movement of mining activity will be clearly revealed henceforth.

1. A.R.H. BAKER, op. cit.
2. A.R.H. BAKER, R.A. BUTLIN, A.D.M. PHILIPS, & H.C. PRINCE, 'The Future of the Past', Area 4, (1969), p 47

PART ONE : THE GROWTH AND MOVEMENT OF OPERATIONS

Since coal resources are finite and are not in any realistic sense replenished, coalmining activity is necessarily a process of diffusion. The movement of hewing or cutting into new coal must leave exhaustion in its wake. Unlike other forms of economic activity, agriculture for instance, mining can never take place twice in the same place and therefore constant locational change is inherent. This occurs at various scales from the forward movement of coal-cutting at any active coal-face to the changing theatre of operations on a coalfield or in the context of a national industry. This process of diffusion is related to but separable from the process of growth and decline. The rate of diffusion is affected by growth but diffusion continues without growth and even during decline. This creates complications which have not always been appreciated by writers on the coal industry. The use of words such as expansion and colonisation to describe the development of coal mining is problematical. Expansion, interpreted as the extension of operations from an original core, can occur without any growth in production. The use of the word colonisation, analogously to agricultural or political colonisation, leads to further semantic difficulties since coalmining is not self-sustaining.

The local movement of coal-cutting can be immensely complicated. It occurs in three dimensions so that mining can take place at the same intersection of longitude and latitude on the surface of the earth, if two or more seams are being worked but never at the same junction of longitude, latitude and depth (bathytude ?). Where the 'bord and pillar' method of extraction was used there were two phases of mining. Firstly, about two-fifths of the coal was extracted from the 'whole' mine as pitmen worked along the bords, which were tunnels, normally four feet wide and six feet apart. A second phase of 'pillar' or 'broken' working accounted for most of the remainder of the coal. Working pillars was more dangerous and was usually carried out in retreat back towards the pit shaft. The two phases did not necessarily occur in immediate sequence. The economics of working whole coal and pillars were different and a period of years might elapse between the commencement of the second and the completion of the first. Furthermore large barriers of coal of varying thickness, but normally amounting to many thousands of tonnes tons, were left separating collieries in order that seam drainage and ventilation might be carried out independently by each. Sometimes these were thinned or completely removed in another phase of extraction. In addition the spatial pattern and nature of mining within each colliery was affected by a whole range of physical factors of a lithological, hydrological and tectonic nature.

Much of the explanation which follows refers to the individual colliery, both as a unit of production and organisation and as a geographical entity. But there were great variations in the nature of the colliery and these are worth preliminary recognition. During the period under consideration here most collieries were concerned with the exploitation of coal within a pre-existing areal unit. This unit was usually an estate, and formerly a manor, the boundaries of which coincided with the limits of underground working. Benwell Colliery, for instance, mined the coal underneath the manor of Benwell, and the same applies to nearly all the collieries mentioned, although many worked small areas of coal from adjacent estates 'by outstroke'. A more complex pattern did emerge on the eastern rim of the Wallsend Basin, where Percy Main, Burdon (or Collingwood) Main and Howdon Collieries cannot be identified with a single estate, but the map of surface estates, Figure 7 , is nevertheless essentially a map of coal royalties even though every estate did not nurture a discrete colliery.

The physical nature of the colliery changed remarkably between 1600 and 1850. It was transmuted from the scores of individual pits which spread like a scourge across the surface of a seventeenth century manor to the large, easily recognisable, pit head, with winding gear, steam pumping engine, screening facilities and other plant, established at a single site by the nineteenth century. Various aspects of this transition will be explained later. Clearly the term colliery does not allow a simple definition.

It is worth eradicating one other source of terminological confusion before explanation begins in earnest, the distinction between the winning and working of coal. The two processes, although quite separate, have frequently been confused in the past. For instance, W. Smith writes "It is true that the actual winning of coal - hewing at the coal face - was still a handicraft ..." [1]. The winning of coal describes all those initial measures, such as sinking, driving headways, drainage and ventilation, which must be taken in order to make coal accessible to the hewer. The working of coal is the process of extraction to the surface which includes hewing at the coal face. The two terms are hardly ever confused, or used interchangeably, in the documents.

In order that the explanation may be followed with reference to a geographical framework three maps of the study area are presented at this point. Figure 7 shows the main coal royalties in the area and

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1. W. SMITH, <u>An Historical Introduction to the Economic Geography of Great Britain</u>, (1949), p 160.

enables the general position of most of the Northumberland collieries mentioned hereafter to be fixed. Figure 8 gives an impression of the topography of the High Main Seam, the most coveted during the period here under consideration, and shows something of the geological nature of the coalfield. The coal measures are synclinal in attitude with two zones of outcropping, parallel to the coast and along the western rim, separated by a furrow of deeper coal in the middle. At the same time the dip is inclined towards the south with the deepest coal at the centre of the Wallsend Basin. The trough-like nature of the coalfield is interrupted, however, by the 'Ninety Fathom Dyke', a fault-line to the north of which the strata have been depressed by about 550 feet (167 metres). The approximate position of other seams in relation to the High Main can be gauged by reference to Table 13. Finally, Figure 9 reveals some aspects of relief, drainage and settlement in 1828. It is adapted from Greenwell's map of that date.

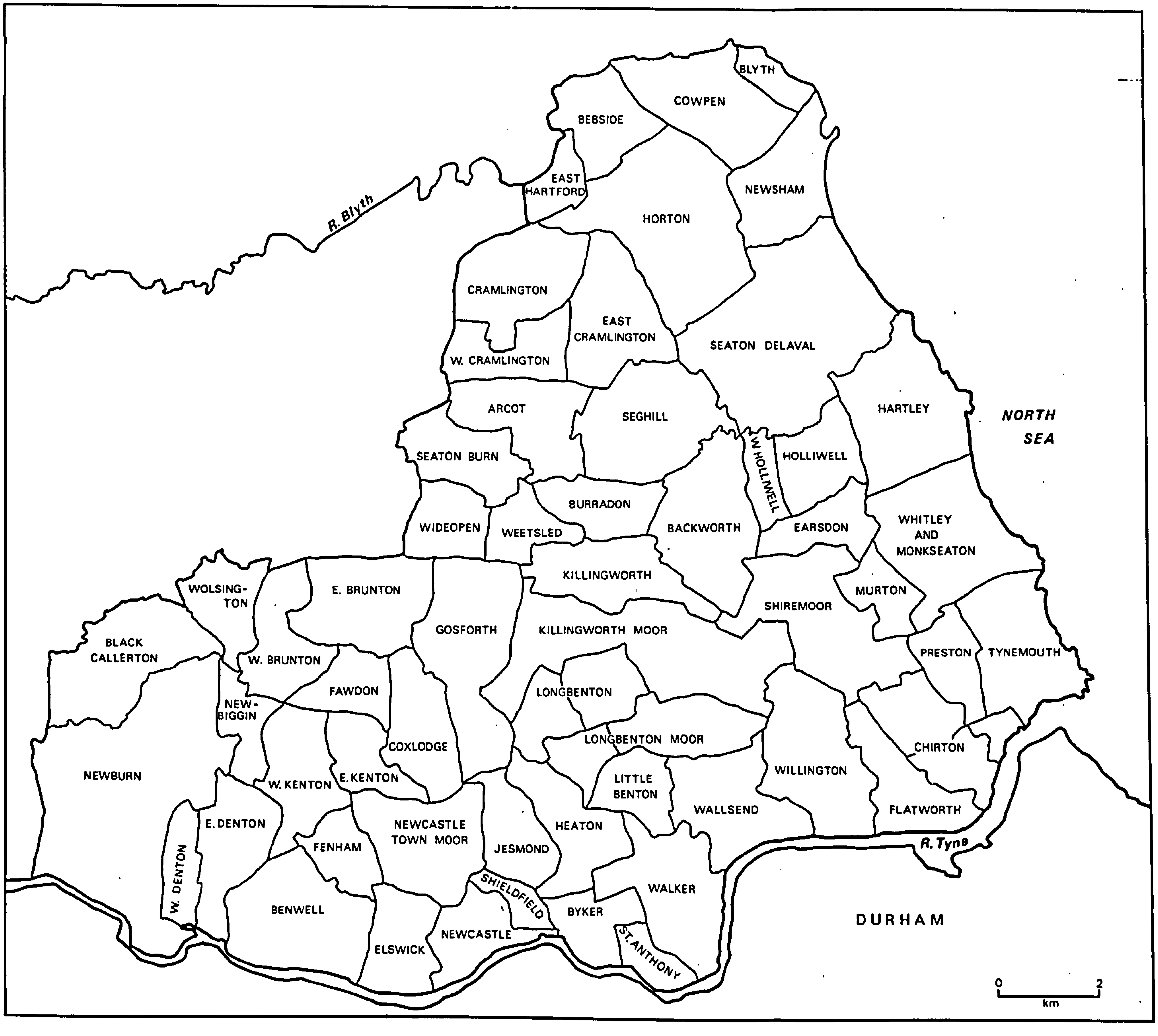

Figure 7 : The mining royalties of south-east Northumberland (1847)

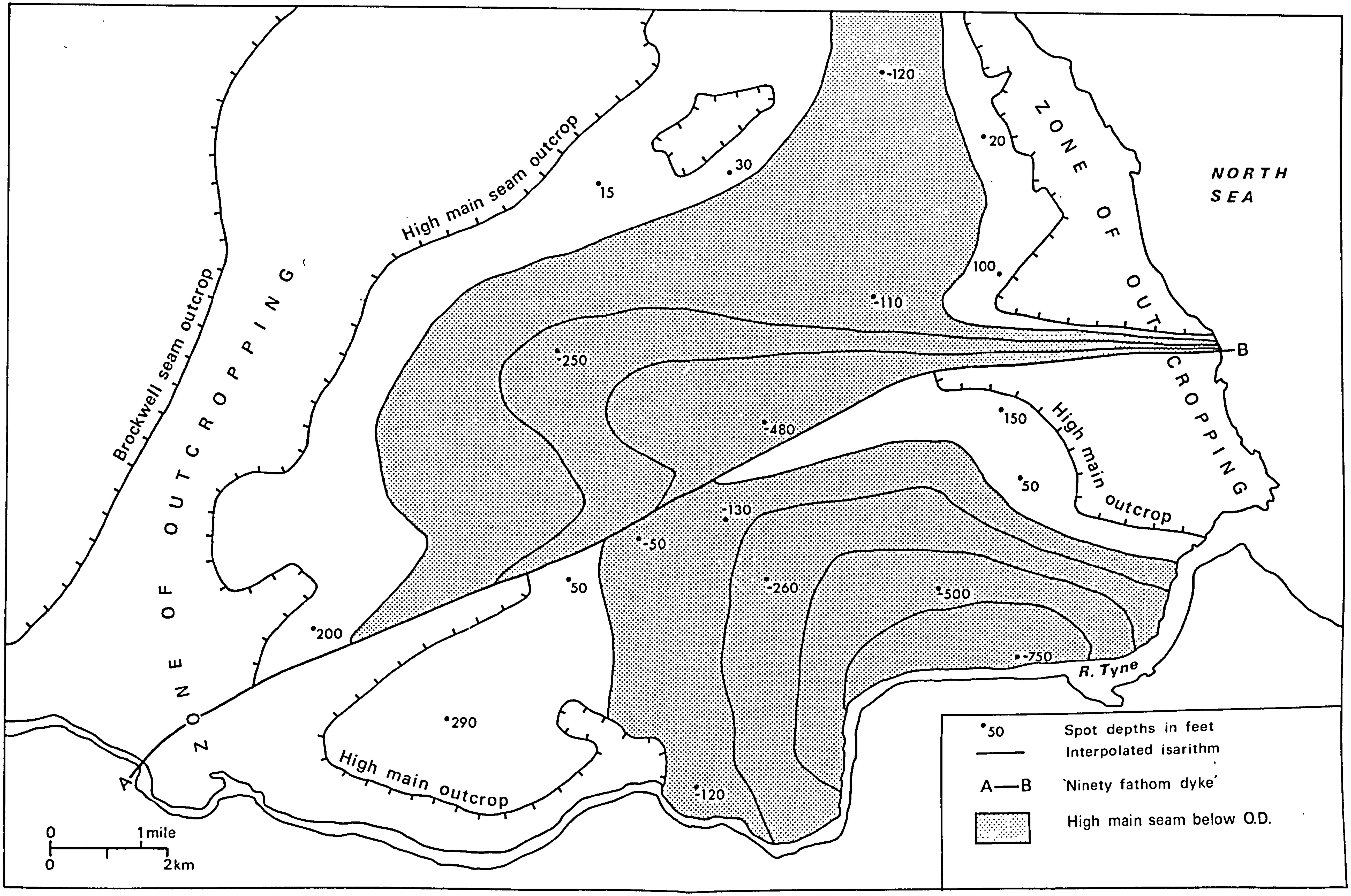

Figure 8 : The topography of the High Main Seam

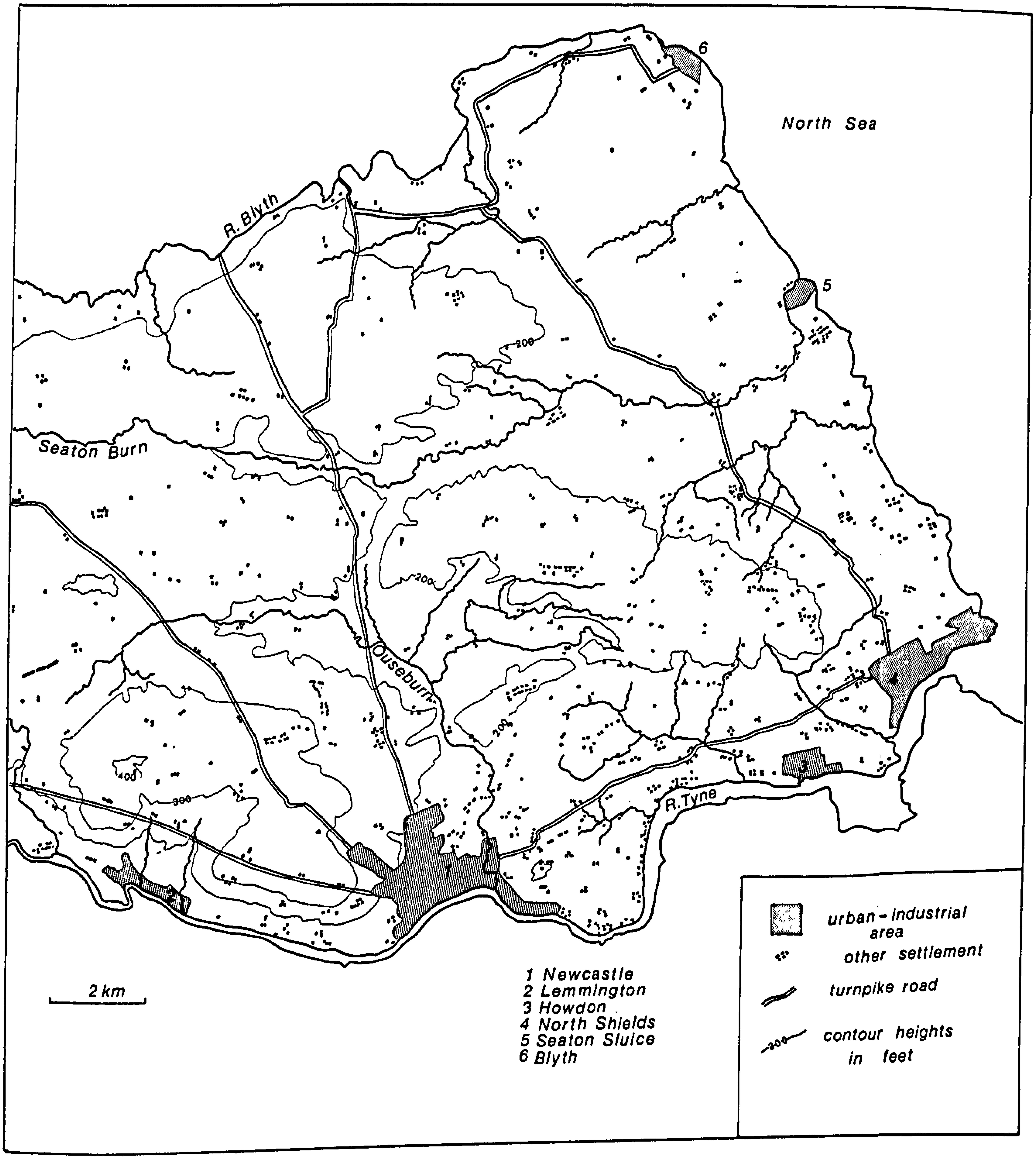

Figure 9 : The surface of the coalfield in 1828

CHAPTER TWO

THE MOVEMENT AWAY FROM THE OUTCROPS, 1600 to 1700

The coal trade of the north-east coast was carried on on a small scale from the end of the thirteenth century [1] supplying London, the east coast of England and some foreign ports with small quantities of fuel but so long as supplies of wood lasted both industrial and domestic users showed no great willingness to burn coal. It was the rapid rise in the price of woodfuel in the later sixteenth and early seventeenth centuries which necessitated the substitution of coal for wood by both industrialist and householder, especially in the London area, and gave the economic stimulus for the rise of the British coal industry. This, combined with the vital changes in mineral control following the transfer of ecclesiastical property into lay hands during the sixteenth century, provided Nef with an explanation for the sudden surge in coalmining activity in the first half of the seventeenth century [2]. No area was affected by the early rise of the coal industry as profoundly as the Tyne Basin where coal outcropped in numerous places, where workable seams ran near to the surface and where navigable water was easily accessible to heavily laden horse-drawn transport.

2.1 The Northumberland coal industry in the early seventeenth century

Figure 10 gives a generalised impression of the location of mining

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1. According to Brand the first mention of sea-coal was in 1246. In 1325 a French vessel reputedly sailed from Newcastle with a return cargo of coal.
2. J.U. NEF, op.cit., vol I, pp 133-64

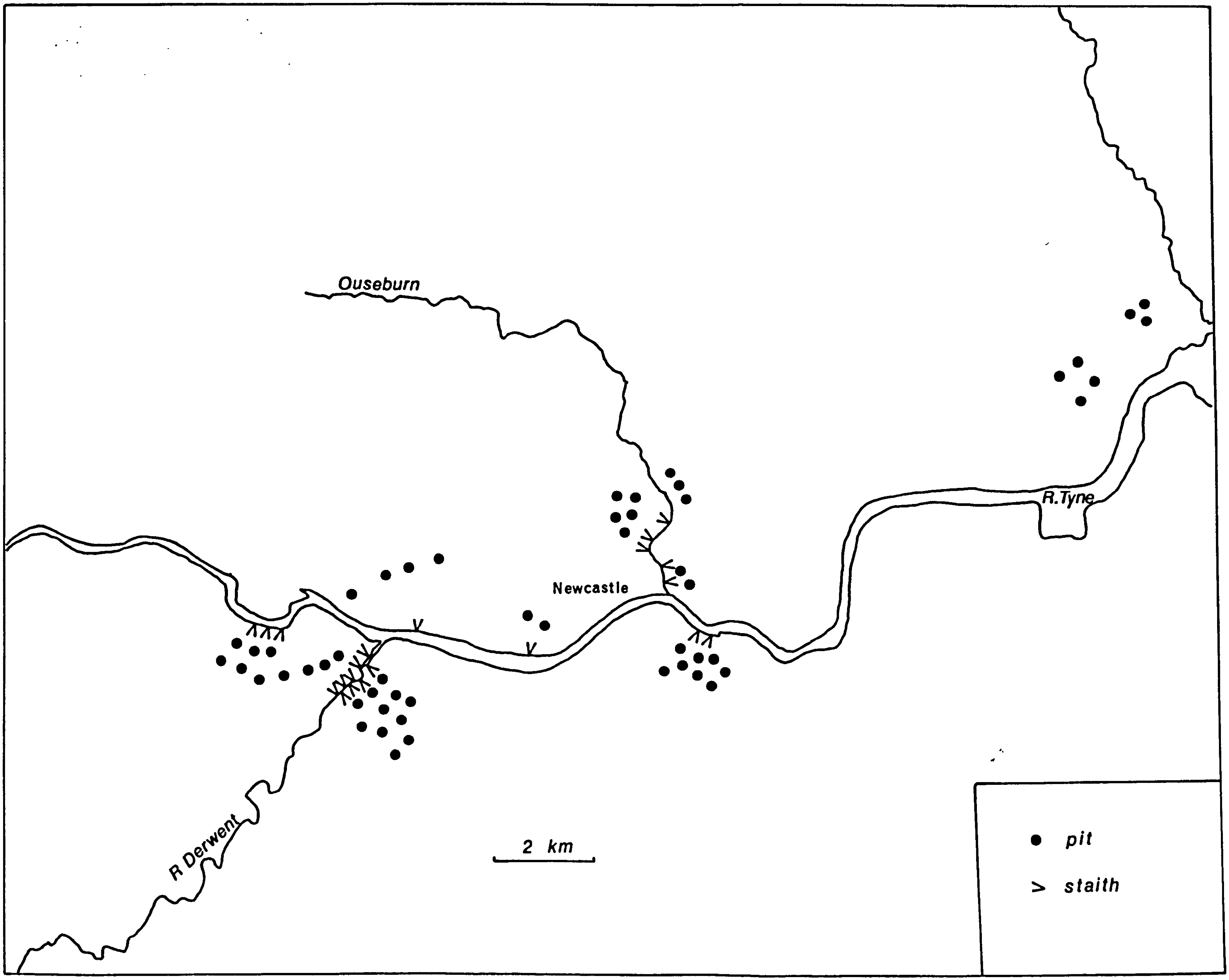

Figure 10 : The distribution of pits on Tyneside in c. 1600

activity on Tyneside in about 1600 [1]. The south side of the river appears to have been the more important at this time. Gateshead, Whickham and Winlaton were the main areas of activity there while to the north of the Tyne a few important clusters of pits were located in the manors of Benwell, Elswick and Newburn, in the lower Ouseburn Valley and to the north of Tynemouth, the latter probably supplying the salt-pans at Shields. The concentration of staiths on the south bank, and at the Derwent confluence again emphasises the importance of the Grand Lease [2] collieries.

This distribution of mining activity is consistent with the very close relationship which existed between technical possibility, the configuration of relief and the position of coal outcrops. Before the arrival of techniques of boring, prospecting for coal was a haphazard business. The whereabouts of deposits were most commonly divined where the presence of coal was obvious at the surface, perhaps in the bed of a stream or on a hillside where strata had been revealed by a land-slip. It was therefore easier for deposits to be discovered in deeply-incised terrain where fluvial and sub-aerial processes were active. Moreover, until methods of prospecting improved and the hazard involved in opening collieries remote from established mining districts was thereby reduced strong forces militated against an ~~aerial~~ areal dispersion of activity. But the relationship between accentuated relief and early coalmining goes

1. H.H.E. CRASTER, Northumberland County History, vol IX (1909), pp 224-5, 'Map of Castle Ward circa 1600'. The precise date of this map is problematical although the distribution shown correlates closely with the documentary evidence for the first decade or so of the seventeenth century.
2. The lease of Gateshead and Whickham Collieries, by far the richest on the Tyne, from the Crown to the Mayor and Burgesses of Newcastle in 1582.

deeper than this. Before the advent of the more effective modes of pumping which came with the use of water and steam power most coalmines were won by 'pit and adit'. This meant that a drainage adit was driven from the side of a nearby valley to meet a seam at a higher level which was thereby drained by gravity. Two important corollaries stem from this. Firstly, only coal which lay above sea level could be drained without additional pumping and at this time modes of pumping were primitive, expensive and often unreliable. Secondly, the 'pit and adit' method of winning coal was most effective where steep valleys were juxtaposed to coal-bearing hillsides. Consequently in the early seventeenth century it was in irregular, hilly and deeply-incised terrain (especially where shallow seams were truncated by the dissection of stream and river valleys) that coal was most conspicuous to the prospector and accessible to the miner. The gorge-like nature of the Tyne valley, and those of its tributaries, the Team, Derwent and Ouseburn, near Newcastle provided ideal conditions for 'pit and adit' workings.

The first documentary evidence of the distribution of mining activity after 1600 results from a survey of coalmines in which the Crown had an interest which took place in 1611 [1]. Unfortunately there were almost certainly a number of collieries, in the Ouseburn Valley for instance, over which the Crown exercised no control since they had not been in ecclesiastical or episcopal hands during the Reformation. Evidence of these collieries at this time is lacking. Nevertheless, allowing for this, it is possible to construct a picture of the broad pattern of the industry at that time. Table 1 is a list of Crown collieries in 1611. The spatial impression given by this data is represented cartographically as Figure 11. It corresponds to some degree with the

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1. PRO, E 178/5037

TABLE 1 : Profit accruing to various collieries in Northumberland and Durham in 1611

		Annual Profit Accruing (in £ - s - d)
Benwell	2 seacoal pits	120
Wylam	1 landcoal pit	30 - 6 - 8
Amble	1 landcoal pit	10
Tynemouth	1 seacoal pit	50
Cowpen	2 seacoal pits	40
Elswick	2 seacoal pits	120
Tudhoe	1 landcoal pit	3
Cockfield	1 landcoal pit	40
Thronley	1 landcoal pit	10
Chopwell	1 seacoal pit	20
Crown Freehold in Gateshead	3 seacoal pits	133 - 7 - 4
Brinkburn Freehold in Whickham	1 seacoal pit	20
Greenlaw Freehold in Whickham	Coalmines	400

Source: S.P.D., Jas I, vol LVIII, 19

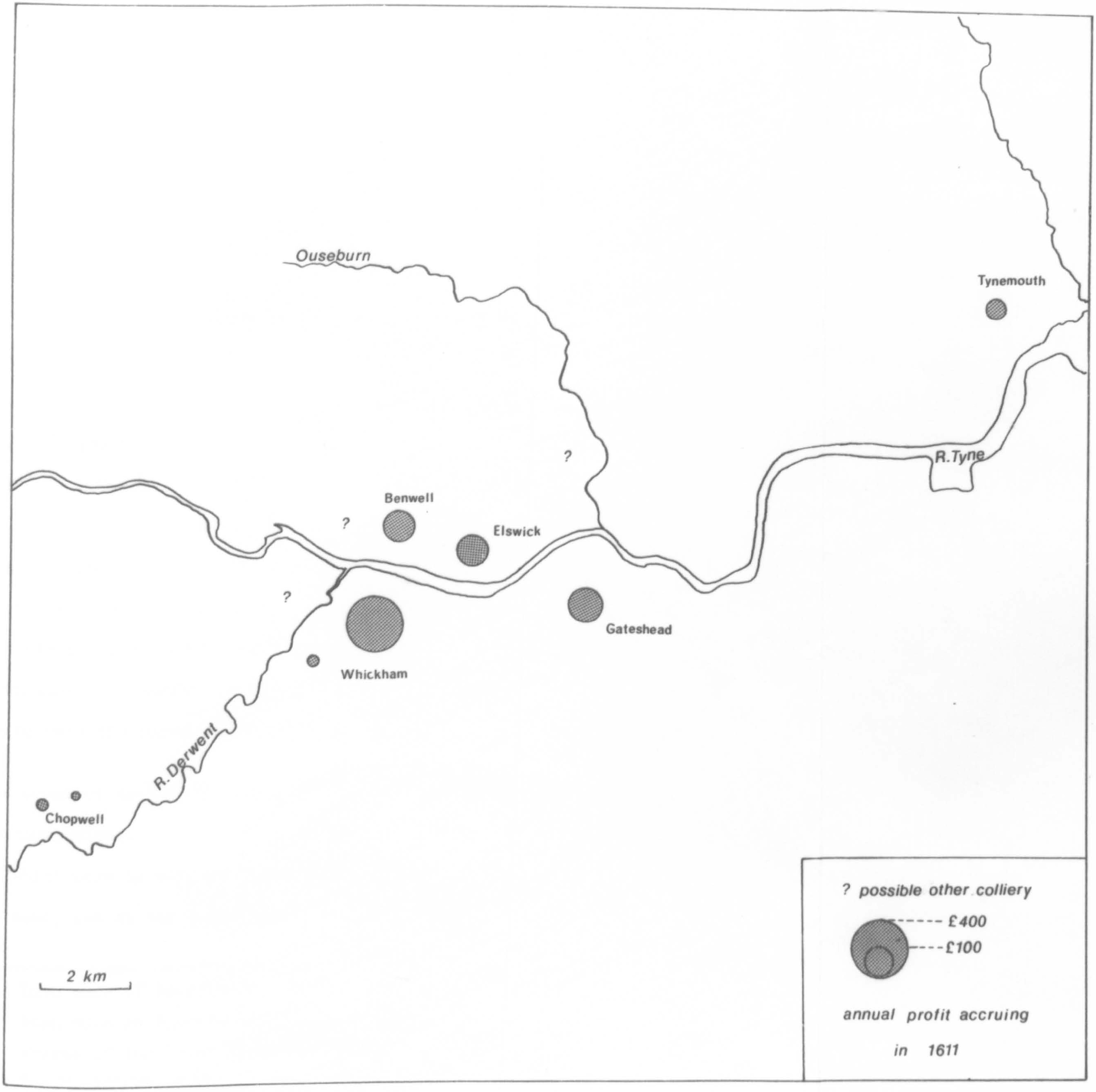

Figure 11 : The distribution of profit from Crown collieries in 1611

impression derived from Figure 10. But Table 1 does not include any collieries in the Ouseburn Valley and probably underestimates the importance of Gateshead and Whickham since only certain parts of those manors are included.

Northumberland had at least two important collieries at this time where coalmining was probably carried on with the same kind of intensity as it was in Gateshead and Whickham. These were Benwell and Elswick [1]. Their significance is not at all surprising. They lay above Newcastle adjacent to the Tyne itself and sloped steeply down to the riverside. They were within the zone of outcropping [2] so that many seams, including the High Main, reached the surface within their boundaries and were ideally situated for 'pit and adit' or simple tunnel mining. In addition, both Tynemouth and Blyth (Cowpen) also appear to have been involved in coastal shipment in 1611 but these collieries became increasingly concerned with supplying salt-pans later in the century. Elsewhere accurate information is more difficult to procure. There were at least two other areas where a significant level of coalmining activity may have been sustained during the early decades of the seventeenth century. These were the manor of Newburn and the lower Ouseburn Valley.

The manor of Newburn was owned by the Percy family, Earls and Dukes of Northumberland. The Percys held many estates in Northumberland, some of which were to support great collieries in the decades and centuries to come, but at the beginning of the seventeenth century only Newburn

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1. Both were of longstanding importance. Over one hundred pits had been sunk in Benwell by 1614 (see p 72) and Elswick was a principal source of the Prior of Tynemouth's income in the sixteenth century. See M. ARCHER, <u>A sketch of the History of the Coal Trade of Northumberland and Durham</u> (1897), p 29
2. Compare Figures 7 and 8.

was capable of competing with those peculiarly favoured Tyneside coal manors which were controlled by the Newcastle magnates [1]. In 1602 Newburn itself was under their control, being leased to a co-partnership of Henry Anderson, Sir Nicholas Tempest, Henry Chapman and Thomas Liddell, all prominent members of the inner circle of the Hostmen's Company [2]. Towards the end of the first decade of the seventeenth century there was a sharp change of policy. The Earl, urged on by his estate officers and notably by George Whitehead, decided to take the mines into his own hands. In 1608 Whitehead wrote to the Earl that he had found a viewer who was not 'bound' to the Hostmen and who claimed that the Newburn mines might produce an annual profit of £400, equivalent to Greenlaw, the most profitable of the Crown's collieries. Various royalties in Newburn were subsequently leased and there appears to have been no shortage of capital. Nevertheless Whitehead's project was a failure. The chief reason for this was undoubtedly the opposition of the Newcastle Hostmen. Whitehead had difficulty in obtaining skilled management and labour because these were monopolised by " the Grand Lease men". In 1617 he wrote to the Earl;

> I fynd all the Newcastlemen very loathe that your Lo: should come in amonge them and therefore noe trust to be reposed in anie of them [3]

By 1618 the Hostmen had closed all outlet and the Earl's coal accumulated unsold on the staiths. An official at the Newburn mines describes the situation:

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1. T.J. TAYLOR, <u>The Archaeology of the Coal Trade</u> (1858). See appendices 5 and 9 for membership of the Company of Hostmen.
2. M.E. JAMES, 'Estate Accounts of the Earls of Northumberland, 1562-1637', <u>Surtees Society</u>, vol 163 (1948), pp xliv - xlviii
3. Ibid.

> We have many coals wrought and can get no vent for them for the magistrates of Newcastle have made such strict orders to ban unfreemen from ventinge anie coales. This is done chieflie to crosse your Lps: officers in the sale of their coales. For certaine merchants that are freemen within the towne, which had undertaken sale of them, have now refused and dare not perform for fear of offence [1].

In 1619 Robert Anderson, Sheriff of Newcastle, and Sir Nicholas Tempest offered to sell the Earl's "ould coles" and any new output up to 400 tens. The Earl accepted, abandoning the attempt to produce and sell his own coal, and the Newcastle monopolists had won another great victory. In 1617 alone, Newburn ran at a deficit of over £600 [2]. In 1620 George Whitehead wrote:

> For the state of your colliery here I need not trouble your Lo: with many lines, for that this bearer will lett your Lo: understand it fully. It is soe bad, I mean not to lay out any more money of your Lops: to be spent on any more hopes [3].

The fortunes of Newburn Colliery in the first decades of the seventeenth century are thus interesting and significant in a number of respects. Here is an example of how the distribution of coalmining is not simply a reflection of technical and economic possibility but also of complex human motives and desires. It is also symbolic of the waning power of the landed aristocracy in the face of the rise of the gentry — the new middle class of ambitious capitalists who were so vital an element in Britain's industrialisation. The pervasive influence of restrictive practices, of which this is the first example, will become clear as

1. M.E. JAMES, op. cit., p xlvii
2. Ibid.
3. Ibid., p xlviii

this explanation unfolds.

The development of mining in the lower Ouseburn Valley, at Byker, Jesmond or Heaton, in the early seventeenth century is much more problematical owing to a lack of direct documentary evidence. Because neither the church nor any monastic foundation was involved in this area, and because lay colliery owners did not advertise the scale or success of their investments, little record of early seventeenth century activity there has survived. Nef makes no reference to it at all. Mark Archer, listing those places in Northumberland where coalmining took place in 1602 mentions Benwell, Brunton, Denton, Elswick, Hartley, Kenton, Newburn, Newbiggin, Newcastle (Forth and Leazes), Plessey and Spital Tongues [1]. This includes collieries (Forth, Leazes, Spital Tongues and Kenton) which may have furnished some 'seacoal' but which were mainly concerned with supplying the city of Newcastle, and also purely 'landsale' pits (Brunton and Newbiggin). But he makes no mention of Jesmond, Heaton or Byker. And yet Figure 10 suggests that there were pits in the Ouseburn Valley. It may be, of course, that the estimated date of the map is wrong and that it refers to a situation existing later in the century. Evidence exists of a considerable revival of mining in the Ouseburn Valley from about 1675 onwards [2] but by this time there were other collieries which do not appear on Figure 10 (notably Hartley and Whitley on the coast). There is also some evidence to suggest that mining took place in Jesmond earlier than this. A release, dated 2nd March, 1659, transfers from John Hodgson's wife and son, Lancelot Hodgson, "... certain messuages and lands in Jesmond, coalmines excepted" but including the "... coalmines under

1. M. ARCHER, op. cit., pp 63-4
2. See pp 87-8

Hodgson's Close"[1]. Although this does not necessarily indicate activity in progress it suggests previous activity, or at least an awareness of potential which could not have been gained without the experience of previous activity. The lack of conclusive evidence means that it is safest merely to presume that Figure 10 shows a distribution of mining activity sometime between 1600 and 1675. In fact, the most important conclusion which arises from all the evidence for this period is that the theatre of mining operations changed very little, even within three-quarters of a century. It was not until after 1675 that new technology, in the form of the water-wheel for pumping and the waggonway for overland haulage, began to stimulate new areas arenas of mining activity.

2.2 Coalmining in the Manor of Benwell, 1600 to 1722

Even after so cursory a survey and before the macro-view is extended in time it is worth deepening the investigation by examining in detail the nature and progress of a single colliery. Fortunately the ~~sources~~ exist records for a fairly detailed examination of changes within one of the most important coalmining manors in Northumberland, the manor of Benwell. Two sources are particularly useful; the reports of the commissioners of the Court of Exchequer who investigated arrears of rents due to the Crown from various collieries early in the seventeenth century and the Benwell manorial records. The former sometimes give a detailed indication of the scale and nature of mining activity. The evidence is presented in the form of depositions of witnesses, usually experienced hewers or overmen, rarely the colliery lessees themselves. Although the deponents were under oath the commissioners obviously were aware of their rent-shy tendency to undervalue the enterprises and treated

1. NRO, Ridley Coll., ZRI/35/22, p 148

with some scepticism their observations regarding profits. Consequently when Richard Robson, thirty-year-old employee of Gateshead Colliery, "... where eight years he hath bene an overman, the rest a workman under the grounde" [1], estimated the annual profit of each pit at twenty pounds the commissioners entered fifty. The impression given by such reports on individual collieries is that coalmining on the north bank of the Tyne in 1611 was in a depressed state. So Nef, attempting to reconcile his thesis of rapid early seventeenth century growth with this impression, suggests that the commissioners "... stood in greater fear of their influential fellow townsmen who worked the crown mines, than of royal power" [2]. To some extent this may be true but it seems unlikely that the commissioners, while perjuring themselves, could afford to paint a picture of a profitless and depressed industry while huge quantities of coal from the Tyne were pouring into the port of London.

Nef also claims that "... the first decade of the (seventeenth) century saw the development of other important collieries on the north bank of the Tyne, at Newburn, Denton, Elswick and Benwell" [3]. This is an exaggeration. The description of Newburn already presented does not really square with Nef's generalisation. At Denton, in 1611, George Watson, overman of the only working pit there, claimed that there was "no wholle myne" and that "a panne coale" was worked from "pillars and Styntens" [4]. It hardly sounds as though an important colliery had developed there during the previous decade. With regard to future operations there, Watson adds that "... whether the same will continue

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1. PRO, E 178/5037
2. J.U. NEF, op. cit., vol I, p 20
3. Ibid., p 26
4. PRO, E 178/5037

fourteene dayes more or less he cannot tell ...".

But Elswick and Benwell appear to have been rather more healthy concerns. In 1611 Elswick had only two rather shallow pits working but "... the seame is two yardes and better in thickness" [1]. An overman and two underovermen comprised the management of the colliery, the most senior of which "... hath been an overman of diverse pitts in these mynes and hath been acquainted with the cole mynes and worked there the space of forty years last past". This testifies to the longevity of the colliery but, again, is slightly at variance with Nef's generalisation.

In 1611 Benwell was the most important of the north Tyneside collieries. It had three working pits and, extending 84, 150 and 192 feet (25, 45 and 58 metres) from the surface, they were the deepest being worked in Northumberland. Oddly enough the seam in each, at only 30 to 40 inches (76 to 102 cm) thick, was not the High Main but was probably the Yard Seam. Consequently, Benwell's produce was only "reasonable good" [2]. Of the three pits one was in a moribund condition, "... the seame is not [cut] ceuten or worked but walls and pillars, noe wholle myne at all", and the future of mining there appears to have been regarded with guarded optimism:

> in the grounds called Pidenge Wood ... there is no colemines which can be gotten or uncovered to have any reasonable continuance ... other than the pit now wrought ... and as touching the two pits in the Haiur Stripe they are very likelie to have continuance from hereforth for twenty years so long as good care be had to keep open the passages of

1. PRO, E 178/5037
2. Ibid.

... water and air and upholding [1]

Clearly mining in Benwell had progressed beyond the most primitive and superficial stage of extraction. One of the pits was almost two hundred feet deep. It had a life expectancy of twenty years. This was obviously more than a simple bell-pit.

The organisation and specialisation of labour was also quite refined by this time. Viewers, overmen, underovermen, bankmen, hewers, barrowmen; in fact nearly all of the elements in the colliery heirarchy on Tyneside were in existence by 1600. Commonly the colliery represented a small group of working pits controlled by a group of capitalists but individually contracted out to overmen who organised actual coal extraction. Thus at Benwell in 1617 John Osborne

> ... wrought one pitt in Stumplewood for Sir Peter Riddle & his ptners. and cast out of the same eight tenns of coales or thereabouts for which the said Sir Peter paid to this deponent fower nobles for every tenn for the workings of the same [2]

There is no evidence that the partnership of Newcastle Hostmen, comprising Sir Peter Riddle, Thomas Surtees, Robert Shaftoe senior, Robert Shaftoe junior, William Hodgson, Henry Chapman and William Jennison, who became "owners, tenante farmers and occupiers" [3] of the

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1. PRO, E 178/5037
2. PRO, E 178/12 Car I/East 25
3. Ibid. When the case against the lessees arose in 1636, however, the defendants were Sir Peter Riddle, Robert Shaftoe, Mark Shaftoe, John Clavering, Albert Hodgson, George Milburn and John Osborne. The last two styled themselves 'overmen-surveyors' and were clearly involved in the supervision of coal extraction. But it is not clear whether they were by this time also part-owners.

colliery in 1614 or 1615, took any direct part in the mining process.

The lease of Benwell to this partnership seems to have initiated a new and rather more vigorous phase of exploitation which lasted from about 1615 to 1631 ~~and~~ during which time some forty-eight pits were sunk within the manor. The distribution of mining activity during this period, and the location of these pits, is shown by Figure 12. Generally the depth of pits at this time appears to have varied considerably. In the Crown Survey of 1611 some twenty-two pits are mentioned in seventeen different collieries. Their depths varied between about forty and two hundred feet and the mean depth of all was seventy-five feet (23 metres). The Court of Exchequer investigation into mining activity in Benwell in the two decades before 1631 preserves a good indication of the scale of operations. For instance, James Barton, one of the witnesses, states that

> ... he wrought in one pit ... at the lower end of Stumplewood by the space of twenty dayes together and that the said pitt was wrought to sixe barrowmen Rancke (every barrowman Rancke being twenty yardes) and that the said pitt did every worke day caste twenty score of bowle corves of coale [1].

Thus it appears that the scale of underground workings were measured in 'barrowmen rank', each unit representing a distance of twenty yards from the shaft bottom. Another witness, John Smith, was a corver-sinker at Benwell and worked for three or four years in three pits which George Milburn had opened in the Meadowhead. Those three pits produced daily

1. PRO, E 178/5996

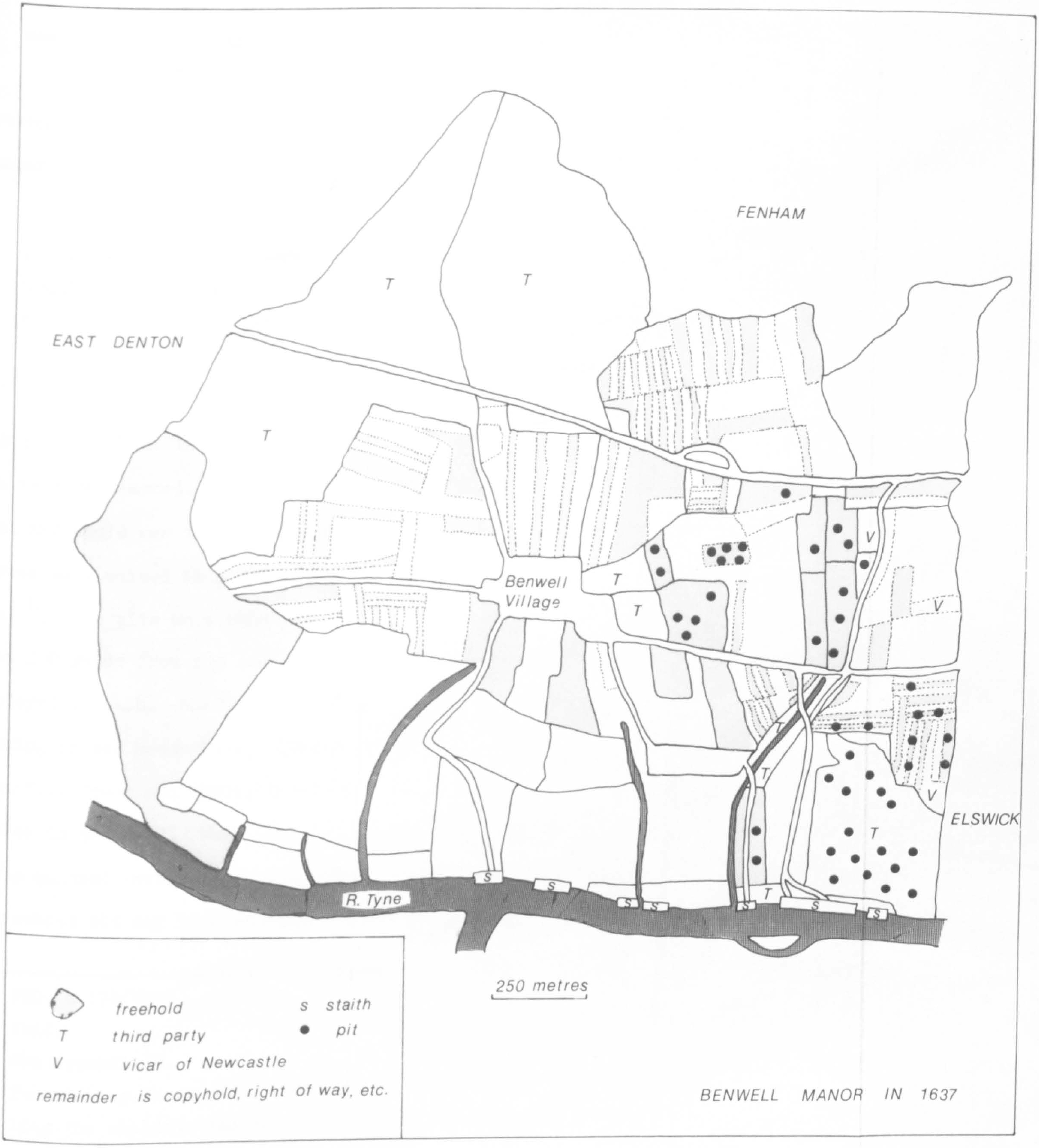

Figure 12 : The Manor of Benwell in 1637

> ... twenty score bowle corves of coal of thereabouts and were wrought to eleven barrowmen rancke and that there were for the most part of the said tyme nine hewers in the said pits [1].

Between 1617 and 1624 another overman, Richard Richardson, opened a number of pits in a three-quarter seam in Stumplewood and

> ... for the space of seaven years together the said pits usually cast every worke day twenty score of sixe peckes corves of coale and were wrought to six or seaven barrowman rancke [2].

A good deal about the scale of mining in Benwell between 1615 and 1631 can thus be learned. The Meadowhead pits were working a five-quarter coal and could use the larger boll corf of eight pecks [3]. Four hundred corves were raised in a day's work, representing about 44 tonnes of coal [4]. The pits were sometimes worked until the coal faces were more than 200 yards from the shaft bottom and nine hewers were normally employed in each. Another witness, John Currie, who was an overman working in the Meadowhead, claimed to have worked from the five-quarter seam "... fower and twenty score of corves being a tenn and a halfe of coales in one day". This represents about 53 tonnes a day. Computing three hundred working days a year and a daily output of 50 tonnes, a Meadowhead pit may have produced 15,000 tonnes annually. The pits in

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1. PRO, E 178/5996
2. Ibid.
3. See Appendix E.
4. Translating these units into tonnes is problematical. Some units, like the chaldron and the ten, varied considerably. According to Buddle in 1828 the boll was equivalent to eight pecks or two and five twenty-fourths of a hundredweight (see Appendix E). The estimates above are based on this relationship.

Stumplewood working the thinner three-quarter coal could use only a six peck corf and were abandoned when the faces were between 120 and 140 yards (109 and 127 metres) from the shaft bottom. The pits at the head of Stumplewood and in the Cross Flat worked the Stone Coal, only twenty inches (51 cm) thick, and could raise only sixteen scores a day. Thickness of seam was obviously crucial to productivity. The High Main Seam, presumably the Ten Quarter Coal referred to here, appears to have been almost exhausted in Benwell by this time [1].

all It is unlikely that ~~the~~ pits in a locality were worked simultaneously. William Brown deposes that the pits worked by Richard Richardson and Patrick Ternent in Stumplewood were "... all worked for the space of six months a peece" [2]. There is also evidence of piecemeal 'broken working'. In 1627, for instance, Bartholomew Lilburn worked out of "... one other old pitt in the Spittle Flat ... in the space of 7 weeks 20 tens of coales". In the same year the same overman worked a hundred tens in nine months from two pits in Cross Flat and yet "... the said two pitts was all wasted and fully wrought exceptinge walls and pillars"[3].

Table 2 summarises the evidence of this phase of mining in Benwell and accords well with the survey carried out by William Brown and Matthew Hodgson;

> ... by the survey and viewe of this deponent Matthew Hodgson

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1. Or, at least, the most superficial and accessible deposits of the High Main. Deeper deposits in the northern part of Benwell may have been mined later in the century when Benwell and Fenham were worked together.
2. PRO, E 178/5996
3. Ibid.

TABLE 2 : Mining activity in Benwell between 1615 and 1631

Location	Date	Overmen	Units	Output (in tens)	Scale (barrowmen rank)	Seam
Meadow Head	1615 - 24	Alex Osborne John Currie Geo. Milburn	8 pits	1 x 300 1 x 17 6 x 200	11	Five Quarter
Stumplewood	1617 - 24	Rich. Richardson Pat. Ternent	7 pits 1 pit	7 x 70 1 x 70	6 to 7	Three Quarter
Cross Flat	1617 - 20 From 1621	Alex. Osborne Richard Richardson Bart. Lilburn Geo. Dell	2 pits 24 pits 4 groves	? 24 x 70 4 x 30	9	Ten Quarter Stone Coal
Legar	1623	John Currie	1 pit	1 x 40		Five Quarter
Stumplewood Head	From 1624	Rich. Richardson	4 pits	4 x 40		Stone Coal
Spittle Flat	1627	Bart. Lilburn	1 pit	1 x 20		

Source: PRO, E 178/5996

> & William Browne one hundred pits and seaven groves (have been) suncke and opened & likewise that there hath been fortie eight pitts and fower groves suncke wrought and opened within the space of twenty yeares last past in the Meadowhead, Stumplewood, Stumplewoodhead & the High Cross [1]

There were thus forty-eight pits and four groves (tunnels or trenches) sunk in Benwell between 1615 and 1631. John Smith estimated that this period of activity had yielded 6,000 tens of coal but William Browne reckoned about 4,000 tens and his estimate is close to the output figures in Table 2 (total 4,037 tens). If, as John Currie states, 24 score of one-boll corves is equivalent to one-and-a-half tens, then 4000 320-boll tens may have yielded about 160,000 tonnes of coal.

It seems probable therefore that Benwell at this time could not have produced much more than five hundred tens per year at full production. The original ten was equivalent to ten chaldrons. This would make the output five thousand chaldrons per year. In 1707 Benwell Colliery vended 13,190 chaldrons [2]. But the hazards of drawing eighty-year temporal comparisons in the seventeenth century are very great indeed. During the century the Newcastle chaldron represented a decreasing quantity of coal as the fitters, attempting to maximise their profits, tended to give short measure. If the Benwell ten in 1631 was equal to 320 bolls, then the chaldron would comprise 32. Yet the Act of Parliament of 1678 certified that a chaldron must contain 21 bolls. By

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1. PRO, E 178/5996. Nef seriously misinterpreted this data. He writes, "According to the deposition made to the Commissioners by Guy Smith, a freeholder in Benwell ...the mine owners ...had dug in all 148 pits and eleven 'groves' during a period of twenty years". See J.U. NEF, op. cit., vol I, pp 370-1. In fact, Guy Smith's deposition, quoted above, makes no such claim.
2. NRO, MBE/IV/5

1740 there were generally only 19 bolls in a chaldron.

Because the units for measuring coal were not stable before 1700 it is very difficult to draw quantitative comparisons in time and space. It may be presumed that the smallest unit, the peck, was relatively stable but the production of,pits was normally measured in scores of corves and the size of the corf increased progressively [1]. The Newcastle 'bowle' or boll appears to have always been equivalent to eight pecks. But the number of bolls in a ten varied considerably. Even in 1828 there were tens of 418, 420, 440, 442 and 528 bolls in use at different collieries on Tyneside [2]. By the early eighteenth century a fairly stable formula began to be adopted by which the ten was equivalent to 22 waggons of 19 bolls each and there were 19 bolls to a chaldron. But some collieries which were slow to adopt waggonways and persisted with wains and carts, Jesmond and Elswick for instance, continued to use tens of 315 to 340 bolls. Such a bewildering complexity of measurement means that the utmost caution must be used when comparing the output of different collieries before about 1730 and especially when converting units of cubic capacity into units of weight. .

There is little precise evidence of the progress of mining in Benwell in the two decades after 1631 but there appears in 'Robert Shaftoe's Book' [3] an outline of the map of 1636 which shows a completely different pattern of mining and which may be dated 1661 [4]. This outline has been reproduced as Figure 13. A most startling development is evident from

1. See p 297
2. NEIMME, Buddle Coll., vol 14, p 425
3. NRO, MBE/III/1
4. The entries in the book appear chronologically so that, although the map has no date on it, its date may be estimated with some precision.

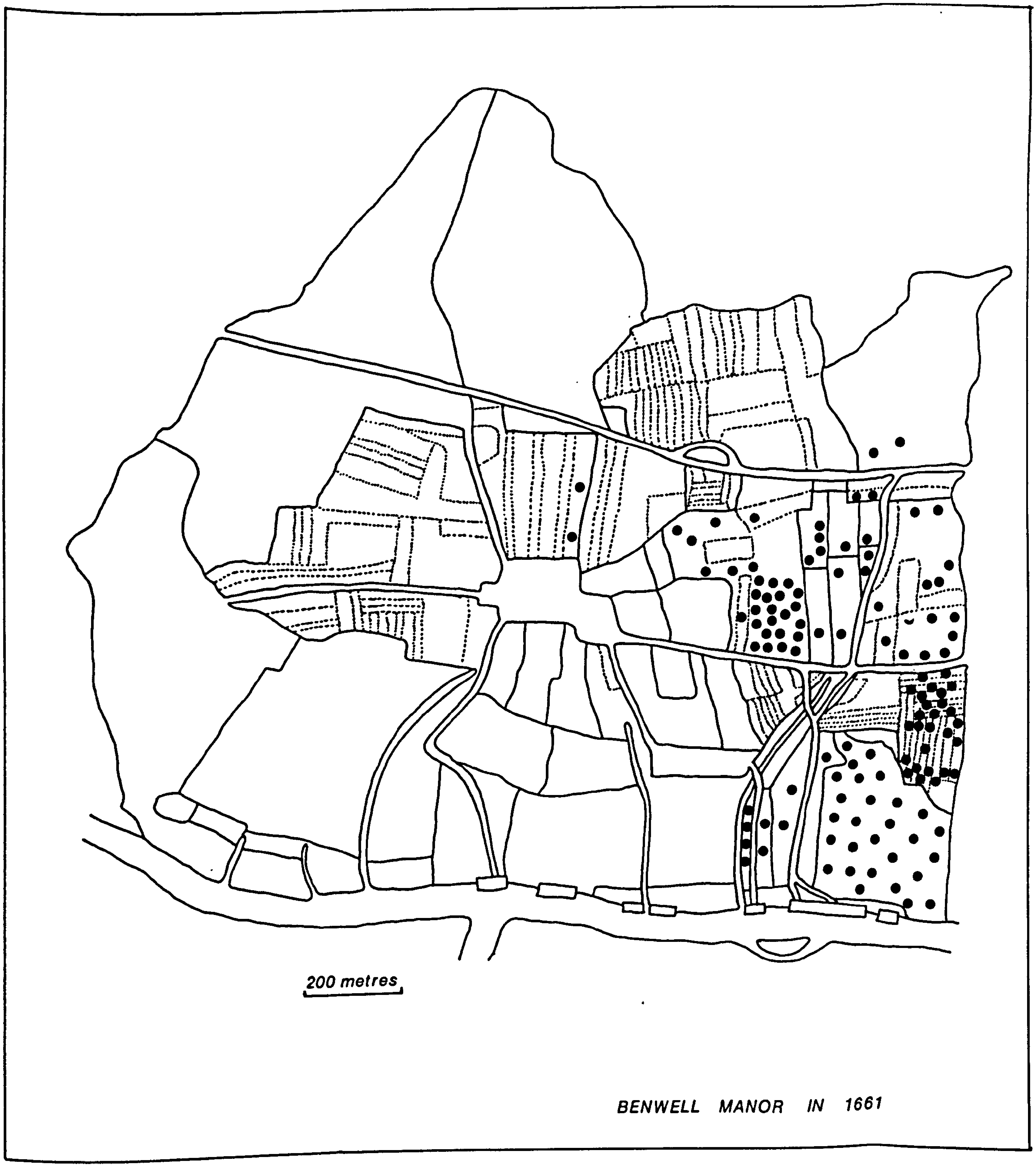

Figure 13 : The Manor of Benwell in 1661

this map. In 1636 most of the pits which were not in Stumplewood were sunk on freehold land. In 1661 the majority of pits outside Stumplewood were on copyhold land. Probably the main reason for the initial unwillingness of the mine owners to open pits on copyhold land was that the copyholders had a right to compensation for the damage done to their farmland by mining. On 2nd May 1650 Mark Shafto said

> I am of opinion that the grounds of the copyholders cannot be opened or broken, or any other spoyle or loss done to the said grounds without satisfaction or recompence (sic) to be made unto them by the owners of the mines for such loss and spoyle, for otherwise the copyholders should pay their rent and have no profit at all which cannot be done by any grant, t'is true if the mines and grounds had been both in one hand in Demaine by such a grant of the mines wayleave might have been granted but it is not true in this case [1]

But the freehold lands were 'in one hand'. Initially therefore the line of least resistance for the mine owners was to negotiate terms with the freeholders. Working coal from copyhold land involved not only obtaining a lease from the landowner but also agreeing terms for compensation with the copyhold occupant. Why then had so much copyhold land been colonised by 1661? Possibly because most of the more easily accessible coal under freehold land had been exhausted and the pressures on the copyholders to allow wayleave and pitroom had become irresistable. Alternatively the landowner may well have bought out the copyholders shortly after 1650, and then initiated an intensive phase of coal-working under their lands. In any case the manorial structure in Benwell was breaking down and the pattern of ownership changing as a result. When a dispute arose concerning rent from land in Benwell owned by the

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1. NRO, MBE/III/1

Vicar of Newcastle, Robert Shafto, in 1719, referred to

> ... an old survey in my Great Granfather's time. Benwell is so much divided and changed since that time, that nobody knows where to find the vicker's land [1].

Indeed maps of Benwell in the early eighteenth century [2] show that enclosure was well advanced by then and the subdivision of fields into 'riggs' and 'stents' had almost disappeared.

After 1631 Benwell appears to have become a pan-coal colliery. Before then its produce was "very good cole" but from 1634 Sir William Selby

> ... wrought dvers. coles within the manor of Benwell which are accounted a base kinde of cole and sometime he looseth as well as he gaines and makes noe profitt thereby because of the charge of the water and other charges ...[3]

Hereafter the coal industry appears to have gone through a period of considerable strife. In 1636 the plague in Newcastle killed an estimated 5,037 people [4]. Four years later royalist Newcastle was occupied by a Scottish covenanter army. At that time its coal trade is estimated to have employed 10,000 "... all the year long, some working underground, some above and others upon the water in keels and lighters ..." [5]. In 1642 Parliament prohibited coal shipments from the Tyne and the restriction remained in force for two years. In 1654 a strike of the

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1. NRO, MBE/III/1
2. For instance, see PRO, MPA/23
3. PRO, E 134/12 Car I/East 25
4. M.A. RICHARDSON, <u>The Local Historian's Table Book</u> (1841),vol I, p 245
5. Ibid.

keelmen brought over three hundred river craft to a standstill and in the following year Ralph Gardiner published 'England's Grievance discovered ...',[1] appealing against the monopolistic privileges of the Newcastle Hostmen. In 1662 two thousand miners congregated on Newcastle Town Moor to sign a petition to the king complaining of unfair treatment from coal owners and overmen [2]. And yet they could hardly have been without work for three years later a crisis arose because of

> ... a great quantity of coals now wrought and lying at the pits which ... cannot be vended in the ensuing summer. The owners of the mines have unanimously agreed that from the first day of May next no coals shall be wrought at any or all of the collierys (sic) at the river Tyne for ship coals [3]

During this period there is little direct information concerning Benwell Colliery. But Figure 13 suggests so considerable an intensification and re-location of activity that the period can hardly have been one of complete stagnation. Moreover, in an account dated 13th July, 1661,[4] there is reference to "Thomas Wakes pittroome in Windyside", "Luke Swan's Pitroome in Nine Akres" and "Hen. Gill his pitt roome in Windyside". More intriguing is an account of working costs for the colliery in 1671-2 which suggests that production for that year was 600 tens [5].

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1. R. GARDINER, <u>England's Grievance discovered in relation to the Coal Trade</u> (1655).
2. M. ARCHER, op. cit., pp 132-3
3. T.J. TAYLOR, op. cit., p 69
4. NRO, MBE/III/1
5. Ibid.

The cost of production for each pit is stated thus:

Wake's pit	56:6	per ten
Wake's pit	40:0	"
Wake's pit	32:0	"
Rutle's pit	55:0	"
Rutle's pit	34:0	"
Widdow Hopper & Shafto pit	48:0	"
Edward Tutipp's pit	43:0	"
Stot's pit	43:0	"
Stot's pit	43:0	"

Although there are numerous references to the colliery like that above there is little evidence to show its precise nature in the last decades of the seventeenth century. In 1699 one of the Benwell pits took fire and burned for nearly thirty years, spreading into Fenham and breaking out at the surface in more than twenty places [1]. Fenham was at that time worked by the owners of Benwell. An account of payments made from the sale of pan coal suggests that the colliery was active from 1672 to 1691 [2]. For the early eighteenth century, however, there exists more precise evidence of a flourishing colliery. Table 3 shows the annual profits and losses from the colliery between 1709 and 1722. It portrays a picture of steady decline. In 1707 13,190 chaldrons of coal were vended from Benwell Staith, in 1708 14,797 chaldrons and in 1709 16,831 chaldrons [3]. In about 1722 the colliery was abandoned and was not re-opened until the 1790s.

Although it has no precise date Figure 14 probably shows Benwell Colliery in the early eighteenth century. It suggests a more co-ordinated and

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1. R.L. GALLOWAY, Annals, vol II, p 163
2. NRO, MBE/IV/4
3. NRO, MBE/IV/5

TABLE 3 : Annual profits and losses from Benwell Colliery between 1709 and 1722

Year	Profit/Loss	Sum (£'s)
1709	Profit	2,227 - 15 - 5¾
1710	"	2,059 - 19 - 11
1711	"	2,594 - 4 - 3½
1712	"	1,784 - 7 - 9¾
1713	"	1,387 - 9 - 5¾
1714	"	1,851 - 12 - 7¾
1715	"	1,488 - 13 - 10
1716	"	949 - 0 - 3
1717	"	608 - 18 - 8¾
1718	Loss	317 - 3 - 4½
1719	Profit	685 - 12 - 10¾
1720	"	167 - 16 - 11¼
1721	"	916 - 2 - 4
1722	Loss	152 - 4 - 7

Source: NRO, MBE/IV/5

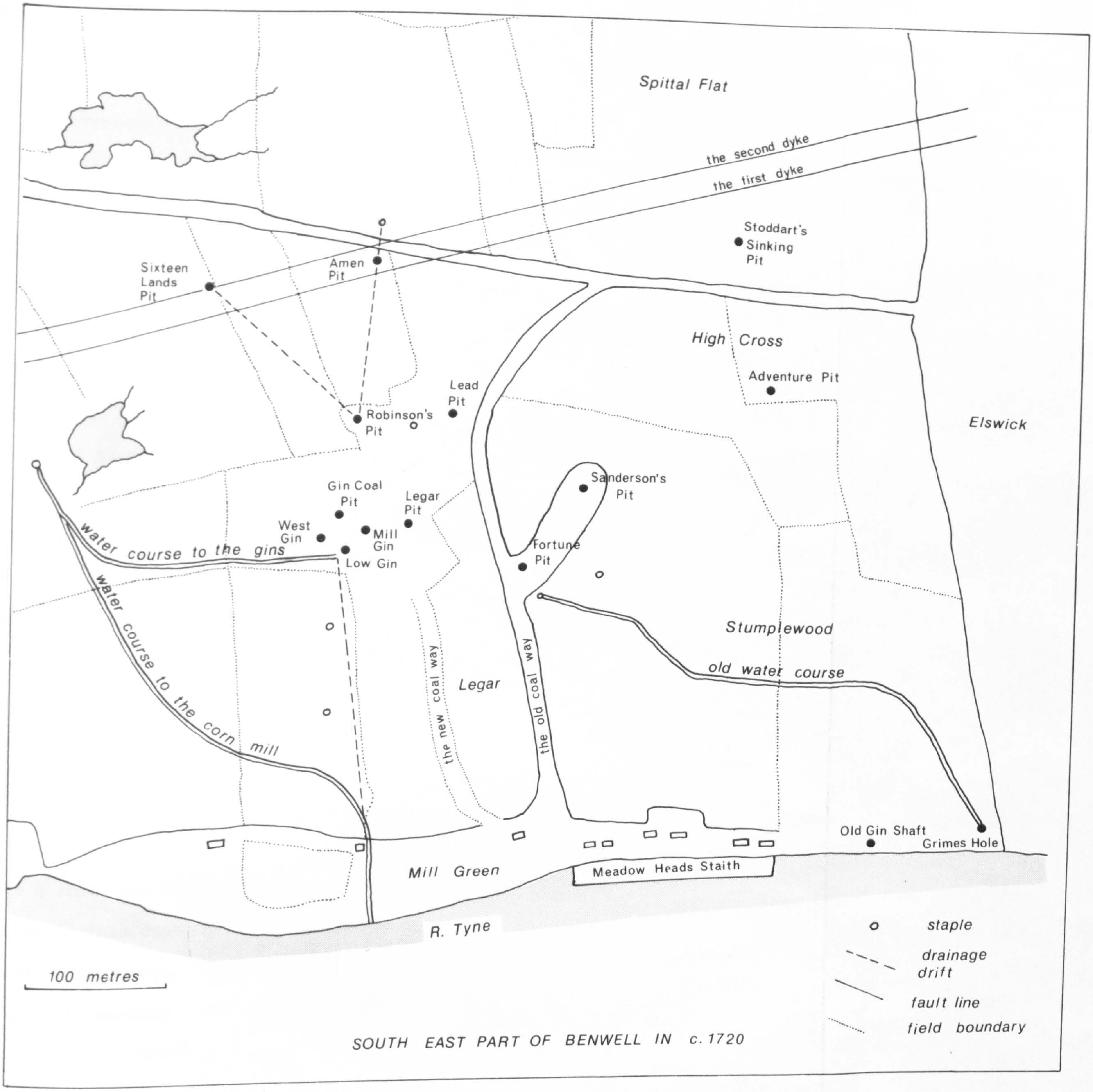

Figure 14 : Benwell Colliery in c. 1720

technologically sophisticated kind of winning with an application of water-powered machinery and a clear inter-relationship of pits.

2.3 Early changes in scale and location

In the seventeenth century there were no massive shifts in the location of coal extraction such as took place in the eighteenth century with the colonisation of the Wallsend Basin and in the nineteenth with the extension of operations north of the 'Ninety Fathom Dyke'. The scale of operations was still relatively small and, consequently, proportionally quite significant increases in demand could be satisfied by an intensification of operations at existing collieries. After all an acre of High Main Coal contained about 261,360 cubic feet of coal, equivalent to about 2,600 chaldrons [1]. Thus an increase in the yearly vend from the Tyne of 20,000 chaldrons, quite substantial for the seventeenth century, could be catered for by working an extra eight acres of the High Main Seam. The manor of Benwell alone was almost one thousand acres and was only a medium-sized royalty. Even within Benwell itself it is remarkable that mining appears to have remained concentrated in the south-east quarter of the estate ~~despite~~ more than a century of after
continuous exploitation. It was quite unnecessary, therefore, for Nef to try to substantiate his claim for a rapid growth in output with associated changes in location [2].

Table 4 shows the output from pits on the Tyne in 1700 and Figure 15 represents this data cartographically. Whether it is a complete list or not is debatable. There is no reason to suppose that any major Tyne colliery is missing. Although the arena of operations was still broadly similar to that shown in Figures 10 and 11 there had been some significant

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1. Accounting 106 cubic feet to the chaldron. See Appendix E.
2. See p 64

TABLE 4 : The output from pits on Tyneside in 1700

Location (owner)	Number of pits	Output (scores of corves per day)
Stella (The Partners)	5 (Main Seam) 2 (Top Seam)	105 24
Stella (Mr John Clavering)	5	104
Stella (Lord Widrington)	4	75
Byermoor (Sir James Clavering)	?	?
Parson's Flat	1	12
Hedley Fell (Beauchamp & co.)	1	25
Scotswood (Sir William Blackett)	3	50
Barlow Fell (Sir William Blackett)	4	40
Swards and Midford Field (Sir William Blackett)	4	42
High Felling (Mr Owen)	2	16
High Park (Alderman White)	?	?
Wilson's Field (Sir Ralph Carr)	4	55
Bensham (The Partners)	2	42
Petty Owners of Gateshead	7	20
Redheugh (The Partners)	2	31
Pape Hill (The Partners)	1	21
Coxclose (Sir Henry Liddell)	3	48
Blackburn (The Partners)	?	?
Tanfield Moor	?	?

Source: NEIMME, Buddle Coll., vol.14, p 212.

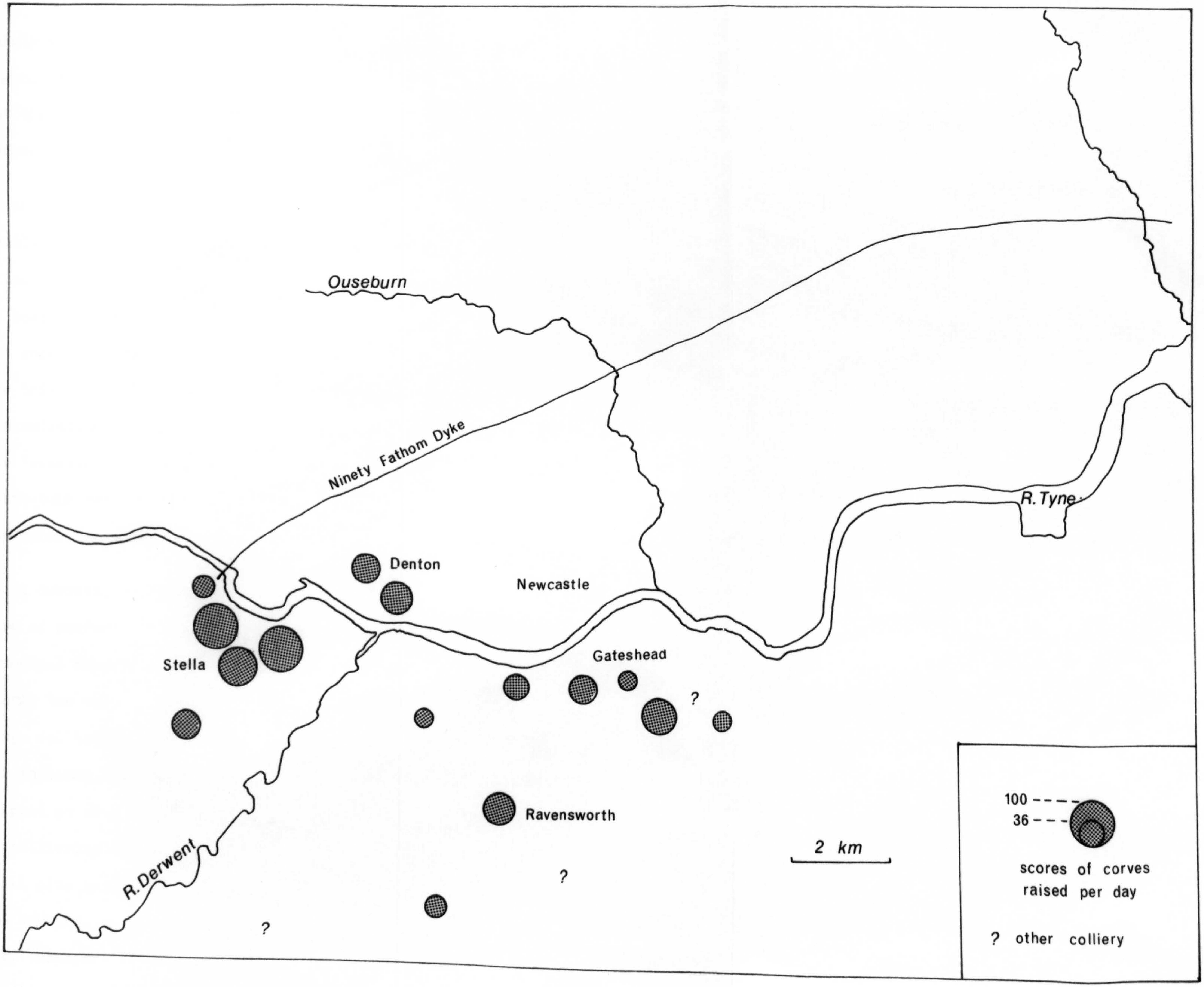

Figure 15 : The distribution of coalmining on Tyneside in 1700

changes in detail. The great areal extension of operations south of the river which was to characterise the next quarter century, and was mainly the result of the introduction of the waggonway, had already begun. Mining in Northumberland appears to have reached a low ebb. But there had been one or two important developments north of the river before this time which are worthy of more detailed consideration.

In the seventeenth and eighteenth centuries Tyneside coal merchants neatly distinguished the markets for their produce as 'seasale', 'landsale' and 'riversale'. The first referred to that coal dispatched on board ship from the Tyne to London, the east coast and foreign ports; the second to coal sold for local household and domestic purposes; and the third to coal used by local industries, especially by the increasing concentration of industrial installations along the riverside. Since the 'seasale' outlet was dominated during the seventeenth century by south-bank collieries much of the mining in Northumberland depended on the other two markets.

Local domestic coal was usually produced by small pits well located for ease of surface haul to the consuming centres. In Northumberland the principal domestic market was the city of Newcastle. Rather surprisingly the coal for Newcastle hearths did not usually come from the large collieries on the banks of the Tyne even though these, Elswick for instance, were even adjacent to the city. Their coal was invariably shipped or sold to local industry. Instead Newcastle's coal was supplied by collieries above the city, on the Town Moor or Castle Leazes, or from small pits in Jesmond or Gosforth, or alternatively from Brunton, Fenham and Newburn, on the high ground to the west. In the days of wain and cart transport it was vital that coal be moved downhill where possible and consequently Newcastle's coal rarely arrived via the Tyne.

Large collieries which were mainly concerned with the London or east coast markets could also sell industrial or riversale coal. However, because most of the early coal - burning (manufacturing, in the form of) glasshouses and salt-pans ~~, was~~ were sited on the river banks ~~and could~~ they could be supplied by keel. The glass industry on Tyneside did not emerge until after 1640 [1] but the sea-salt industry had much earlier origins and, by 1600, the mouth of the river Tyne had become a great centre for the production of salt by evaporation of sea water. At the zenith of the industry's prosperity there were over 230 salt pans at Shields and a few further upstream at Howdon [2]. Nef estimates that maximum production was in excess of 15,000 tonnes per annum, a quantity which would account for the consumption of 90,000 tonnes of coal [3]. According to Brand even by 1605 the consumption of pan coal at all the works in Northumberland and Durham had reached 50,000 tonnes [4]. At least three quarters of this must have been burned on the Tyne. Clearly there was a substantial market for industrial coal which could sustain collieries which were excluded from the sea-borne trade by the poor quality of their produce.

Substantial quantities of dross for the salt pans were certainly shipped downstream from Denton, Elswick, Benwell and Newburn, the Tyne-bank collieries above Newcastle. But a further important area of mining for pan coal existed much lower down the river around Tynemouth. The monks of Tynemouth had worked coal here for centuries. Although the quality was poor and the more accessible reserves were worked out, the growth of salt-making at North Shields created a steady market and, in response,

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1. P. PILBIN, 'The influence of local geography on the glass industry of Tyneside', Journal of the Tyneside Geog.Soc., vol I (1936) pp 31-45
2. G. HODGSON, The Borough of South Shields (1903)
3. J.U. NEF, op. cit., vol I, pp 175-9
4. J. BRAND, History and Antiquities of Newcastle (1789), vol II, pp 241-311

pits were opened in the manors of Tynemouth, Preston, Chirton and Monkseaton. In 1611 there was one pit working in Tynemouth itself, "... the depnes is about fower fathoms, the seam is three quarters, the colle is a panne colle and may have continuance ten yeares if the roofe be noe hindrance" [1]. At Preston the same seam was worked at fifteen fathoms, "a good salte panne colle", "onlye imployed for salte pannes". Coal from these collieries could be transported to the pans a short distance overland avoiding the break-of-bulk which transfer to keels would have entailed. The pans at North Shields, of which the highest recorded number was thirty-two (development was restricted by lack of flat riverside land), may consequently have received their coal at lower prices than those south of the river. It was this fact, as suggested earlier, which could have promoted coalmining at South Shields.

The close juxtaposition of salt pans with shallow coalmines was a common feature of early industrial development in Northumberland and occurred at a number of other locations along the coast. Blyth was the scene of one of the earliest speculations in large-scale salt-making, fostered by Cecil in 1566 [2]. In 1609 the only pit working there was drowned and salt-making stopped for lack of fuel [3]. At Hartley and Amble a similar picture of early seventeenth century depression emerges [4]. The fortunes of salt-making and coalmining in these isolated locations were closely intertwined, so that the factors promoting the growth and decline of one automatically affected the other in the same way. Unlike the pans on the Tyne which could choose from alternative sources of fuel, those along the coast might quite suddenly be forced to cease operations if

1. PRO, E 134/5037
2. J.U. NEF, op. cit., vol I, pp 32-6
3. PRO, E 134/5037
4. Ibid., see also PRO, E 367/3297, 3665, 6986, 4440, 7085

their appurtenant coalmines encountered unexpected difficulties. At Cowpen four salt pans had been leased together with two coal pits at Bebside but in 1637 surveyors reported

> ... the sayd collieryes and saltpannes a mere waste, not having been occupied by the sayd Errington nor anie rente paid since the grant thereof ... the upper coale is quite wroughte out, and the lower maine cole overflowed with water, soe by reason of want of coale the pannes are likewise quite decayed [1]

But in the second half of the century there was a resurgence of coal-mining activity along the coast for which the demand for salt was only partly responsible.

In fact there were two major locational changes affecting the pattern of coalmining in Northumberland which occurred in the final quarter of the seventeenth century. One was the revival and increase of activity along the coast. The other was the commencement of large-scale operations in the Ouseburn Valley. These two developments presaged the shift in emphasis from the west to the east of Newcastle which characterised the eighteenth century.

The arrangement of entries in the port books of Newcastle makes it possible to trace quantitatively the rise and decline of Whitley and Monkseaton Colliery between 1677 and 1726. This is because shipments from Cullercoats, the small harbour two miles north of Tynemouth which handled only coal from that colliery, were entered separately. The trade of Cullercoats depended entirely on one colliery and the salt pans nurtured by that colliery.

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1. PRO, E 317/Parliamentary Surveys/ no 2 (Northumberland)

It was the Percys, here unfettered by the restrictive practices of Newcastle, who built the harbour at Cullercoats in 1677 and leased the colliery as well as sites for salt pans around the harbour [1]. A closely integrated growth of mining and salt-making, and shipments of both coal and salt from the port, occurred from that time. Figure 16 traces the temporal pattern of growth and decline. The interdependence of the coal and salt industries could hardly be clearer.

A few years earlier, in 1670, Sir Ralph Delaval had undertaken a similar project at Hartley [2] and this probably provided some of the stimulus for the Cullercoats venture. The ingredients were the same; the construction of a small harbour on the coast, the vigorous exploitation of shallow local coal deposits and the establishment of salt pans to take the refuse coal which was too poor to be sold in the London or coastal markets. There was also at this time an awakening of activity in the Ouseburn Valley, east of Newcastle. Jesmond, Heaton and Byker all appear to have been worked during the last quarter of the century, though not without difficulty. At Byker

> ... Collingwood, Mitford and Rogers in August 1675 began first to get coles out of the said colemyne in Byker Loaning and that it was difficult and chargeable because of ye abundance of water which cost many hundred of pounds and she was drowned 16th August 1677 and all care was used to prevent it and great sums of money spent [3]

Even the old Tyne-bank collieries above Newcastle showed some signs of

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1. See my article appended.
2. R. NORTH, Lives of the Norths (1890), ed. A.Jessop, vol I, pp 176-8
3. NRO, Ridley Coll., ZRI/29/2

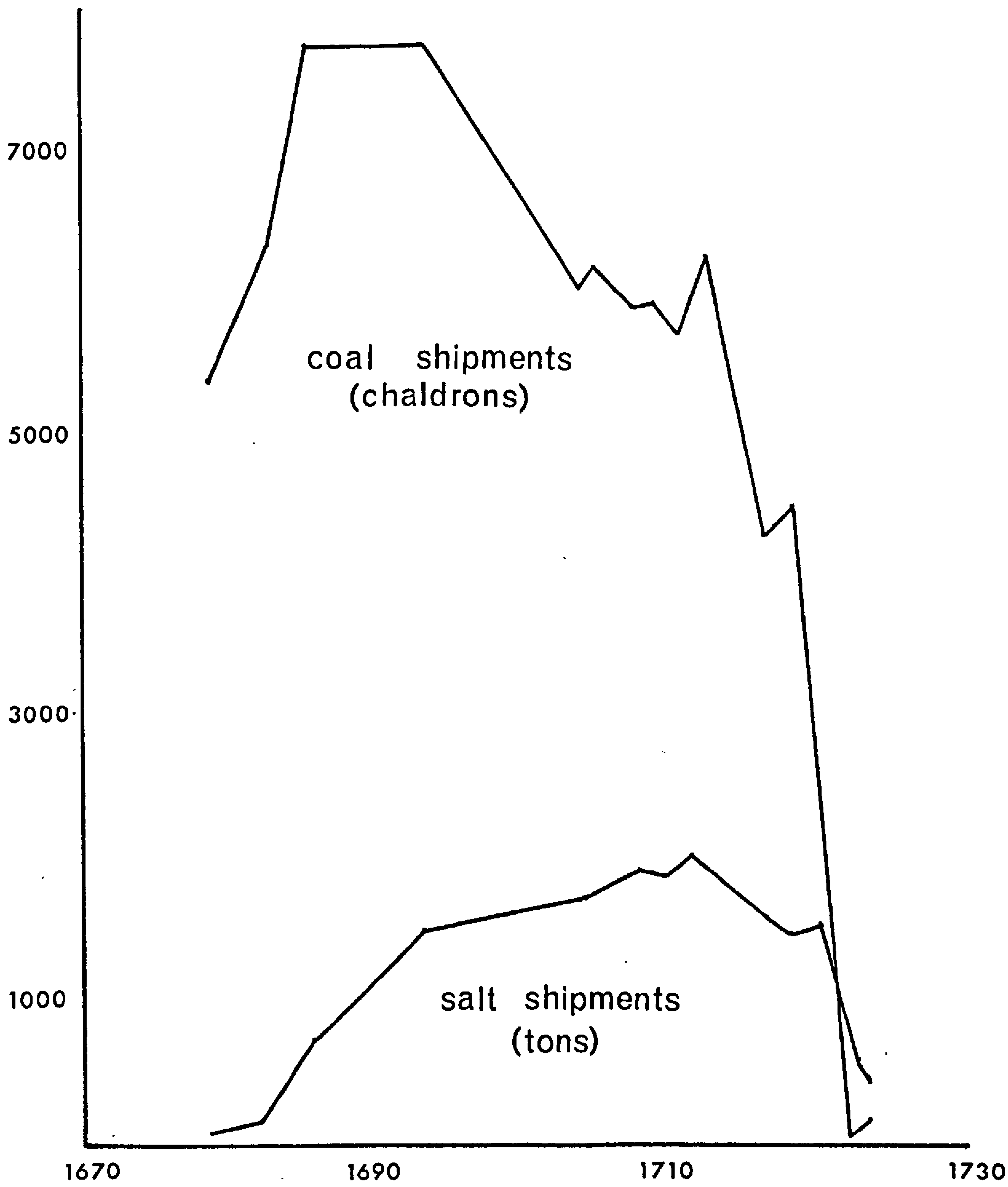

Figure 16 : Coal and salt shipment from Cullercoats, 1679-1726

stimulation at this time. Kenton Colliery was opened by Martin Fenwick in about 1675, West Denton was won by the Erringtons in about 1689 and East Denton somewhat later by Sir James Clavering, John Rogers and Mrs Carr [1].

But why did this sudden increase in activity after 1670 occur? There can be little doubt that it was partly the result of an increase in demand. Figure 24 shows the growth of coal shipments from the Tyne (p 196) between 1660 and 1830 and reveals a clear 'bulge' after about 1670. It may be that some of the main established mining manors above Newcastle bridge were showing signs of exhaustion. They had been intensifying operations in order to supply an expanding market for a century or more. It is significant that, according to Figure 15, Whickham was relatively much less important than it had been earlier and Stella and Gateshead Fell dominated the picture south of the Tyne.

It seems likely that the locational changes outlined above were also linked to technological change. By 1670 a number of important innovations had occurred which altered the range of feasibility in mining. Firstly, prospecting for coal was greatly facilitated by methods of boring which were brought to the north by Huntingdon Beaumont, a Nottinghamshire gentleman who speculated in the coalmines of Bebside during the first decade of the century [2]. Better ways of exploring underground were vital to an economically rational exploitation of coalfield resources. However, it took a number of decades before the necessary skill in the use of boring rods had been acquired by enough people, and before a sufficient number of borings had been made (it was an extremely costly and laborious process), for more certain

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1. NEIMME, T.E. Forster Coll., 49/4, p 37
2. See p 198

calculations of viability to be possible; still longer for even the rudiments of coalfield geology to become clear.

Secondly, by the latter half of the century the new possibilities offered by railed waggonways were being fully digested [1]. The potential economies arising from the use had been demonstrated at Whickham perhaps as early as 1640 and the building of the Ravensworth waggonway in 1669 ushered in a period of railway development. Thus coal resources which lay at greater distances from staith were being brought within the ambit of economical exploitation. The building of an elaborate waggonway linking Whitley and Monkseaton Colliery with the salt pans and harbour at Cullercoats, probably the earliest line in the county, was an integral part of development there.

Generally speaking, innovations which facilitated easier overland transportation were advantageous to more distant collieries whereas innovations which enabled deeper working re-emphasised the advantage of river-bank collieries. The latter comprised the third area of important technological improvement. In the seventeenth century the main advance in coal-winning was the introduction of the water-wheel as a means of driving pumps. This was an important landmark in the development of mining technology since it represented the first use of inanimate power. All pumping and haulage which had taken place before depended on horse or human muscle. As with textiles and transport the development of power technology for the coalmining industry followed a progression in which water preceded steam which, in turn, gave way to electricity and internal combustion.

There is little convincing evidence that windmills were ever used

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1. M.J.T. LEWIS, op. cit., pp 86-110

successfully for drainage purposes in Northumberland though, as in Scotland, the method was certainly tried [1]. Water-wheels relied on an equally capricious climatic element but one which was made more reliable by the fact that reservoirs could be constructed to ensure a flow of water in all but the severest drought. In the second half of the seventeenth century and the early decades of the eighteenth, before the Newcomen engine had become a reliable aid to pumping, water-wheels driving chain pumps, or 'bobgins', as they were called, were widely used on the Great Northern Coalfield. It is no accident that the tributary of the river Team, which even today is called Bobgins Burn (grid ref. NZ 195 566), flows through that area of north Durham between Ravensworth and Tanfield where coalmining expanded most rapidly in the early eighteenth century. In Northumberland both Heaton and Jesmond Collieries were drained by water-wheels in the later seventeenth century [2]. Indeed, the fact that the Ouseburn could be harnessed for water power was probably one important cause of the colonisation of its valley in the decades after 1670. A map of Newburn Colliery in about 1720 shows clearly that a 'bobgin' nourished by an appurtenant reservoir was being used [3]. A 'water engine' is mentioned at Benwell as early as the 1660s [4] and Figure 14 suggests that water-power had played an important role in the development of the colliery before 1722. Considering the wide-spread use of water-power in the leadmines of the nearby Pennines, even up to the twentieth century, it is not surprising that it should have played an important, though more obscure, role in the rise of the

1. There was a windmill drawing water at Ford Colliery, near Berwick on Tweed, in 1764. See NRO, Delaval Coll., 2 DE/6/4, letter from John Allen dated 8 December 1764.
2. See p 275
3. PRO, MP II/40
4. NRO, MBE/III/1

Tyneside coal industry.

In 1700 the Tyneside coal industry stood in a remarkable state of preparedness for the momentous changes which were to take place in the next hundred and fifty years. Even by then it was an old industry. Organisationally it was surprisingly intricate and sophisticated. The rigidity of manorial and medieval custom had been successfully undermined. The power of the church and aristocracy in the ownership of land and minerals had been usurped by the commercial middle class epitomised by the Company of Hostmen. The specialisation of labour and responsibility had attained great refinement. A labour force preconditioned to the customs and skills of mining, deprived of a livelihood from the land and, for the most part, fated from birth to spend half of their lives in subterranean darkness had emerged, the clannish Geordie pitmen. A new industrial heirarchy, almost as feudalistic as the old agrarian one, had appeared. Barrowmen, hewers, bankmen, overmen and viewers were already ranked within it. The collier was not normally a husbandman spending part of his working day digging at the local pit but a specialised artisan who sold his labour and was 'bound' to his employer to work for one year. Perhaps his last tie with the soil was the allotment garden, the produce of which characteristically supplemented his family's diet. Technologically coalmining had also made great strides. Now men no longer needed to rely on discovering by chance a deposit of coal. They could go hunting for it with boring rods. Armed with the new knowledge that natural forces - gravity, the wind, running water - could help as well as hinder them, they had begun the long-drawn-out conquest of the problems of draining mines and transporting their produce. In 1700 the railed way, the keel and the collier brig probably comprised the most effective system of bulk transportation that had existed. But the application of steam power would soon begin to change the nature and geography of the industry as no new method had done before.

CHAPTER THREE

ABSORBING A NEW ETHOS : 1710 to 1760

In the twentieth century rapid change is taken for granted and modern man requires all his resources of adaptability to remain mentally in tune with the different world which is ceaselessly emerging. Although pre-industrial societies were by no means static politically, culturally or economically, the totality of change, especially technical change, normally experienced in a lifetime would, by today's standards appear small indeed. More often than not people could live out their working lives with the same methods and routines which were familiar to their grandfathers and without radical change to disturb the solid equilibrium of tradition. As the process of industrialisation gathered speed established norms were increasingly undermined. More frequently men were faced with the unfamiliar reality of adapt or perish. In the new coalmining areas although people were no more enlightened and natural conservatism was just as strong, change was extremely rapid. The nature of the industry favoured this. The basic economics of mining were quite apparent and clearly understood. The cost-benefit utility of new techniques became evident almost as soon as they were efficiently applied. Also the nature of mining dictated that working became progressively more difficult and coal progressively less accessible. As time went by existing methods were remorselessly tested and almost inevitably enfeebled. Consequently the technological challenge was relentless. As the demand for coal increased new techniques became almost a sine qua non, not only for the industry's expansion but also for its continued existence. The coalmining community in north-east England was one of the first which needed to accept rapid change and the new ethos which went with it.

3.1 The coming of the atmospheric engine

The first attempts at applying Newcomen's atmospheric engine to the drainage of coalmines on Tyneside appear to have been made in the second decade of the eighteenth century. Dunn states that the first engine to be erected north of the Tyne was at Byker in 1714 under the supervision of a Swedish mathematician resident in Newcastle [1]. No documentation of this attempt appears to have survived although there are many references to it in older secondary works. Dunn also states that, by 1721, the 'fire engine', as the Newcomen apparatus was popularly termed, was in general use on the coalfield [2]. This is a dubious generalisation and the impression of a smooth assimilation of the new method which Dunn's few brief comments give cannot be taken at face value. Edward Hughes, in an article which attempts to explain the circumstances under which the first atmospheric engines were erected on Tyneside, uncovers some of the difficulties involved in adoption [3]. He concludes that the inevitable abuses of Savery's patent caused great difficulty in securing the necessary cylinders and expertise and that the initial attempts to erect engines at Gateshead Park, Washington and Farnacres, in Durham, were failures. This is not surprising when the enormous difficulties encountered subsequently in the Ouseburn Valley are considered [4].

In his comments to the 1738 Parliamentary enquiry into the coal trade George Claughton makes no reference to engines, except those in the

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1. M. DUNN, An historical, geological and descriptive view of the coal trade of the north of England (1844), p 22; See p 277
2. Ibid.
3. E. HUGHES, 'The First Steam Engines in the Durham Coalfield', Archaeologia Aeliana, 4th series, vol XXVII(1949), pp 29-45
4. See pp 112-25

Ouseburn Valley, perhaps suggesting that at first only for the Ouseburn collieries were atmospheric engines viable [1]. There are some grounds for believing that this is so. The collieries in north Durham were already burdened with the enormous costs of waggon haulage. The Ouseburn collieries, on the other hand, were near to the Tyne, so haulage costs were not great. But they were working coal which lay below sea level and, therefore, could not rely on free drainage. The north Durham collieries situated in the higher land between the rivers Team and Derwent were shallower and well above sea level, and so could rely on cheap 'pit and adit' methods. It may be suggested, therefore, that there were two kinds of collieries in the first half of the eighteenth century; deep collieries near navigable water with low haulage costs but, because they needed atmospheric engines, high drainage costs; and shallow collieries with low drainage costs but, since they were farther from shipping staiths and needed long waggon-ways, high haulage costs. These latter came to be termed simply 'long ways'. For a time at least it seems that locations which demanded both of the new techniques were not economically viable. The general pattern of innovation adoption supports this rough dichotomy. By 1769 some twenty-two atmospheric engines had been erected in the Ouseburn Valley [2], while the initial development of waggonways was most spectacular in north-west Durham.

But were there any successful applications of steam between the initial, and apparently unsuccessful, experiments at Byker, Gateshead and Washington in about 1713 to 1717 and the winning of Heaton and Jesmond after 1726? In Northumberland there was at least one. Dunn states,

1. NEIMME, Buddle Collection, vol 14, pp 354-365.
2. NEIMME, Shelf 16, Dunn's History of the Viewers, p 14.

with unsubstantiated authority, that in 1725 "Elswick Engine was erected upon Elswick Quay for the purpose of working the Low Main" [1]. This time, however, further evidence has come to light. In the Benwell Manorial Records appears the following undated extract from an "exact survey" of Elswick:

> Elswick cannot drain any other colliery except Benwell and the coals are all wrought away in the drowned part and in ye part which is now going they draw all their water for a small matter at one gin. Besides George Ledgers must covenant he shall not place the fire engine in any other part of Elswick than at the North Pitt or one of the present horse gin pits ... [2].

Accompanying the extract is a plan which shows a winning of Elswick technically very similar to the winning of Benwell shown in Figure 14. The extract also states that "Benwell Colliery is almost quite wrought out even in ye part now going". Since the working of Benwell ceased in about 1722 [3] the preparations described above can be dated to about then and obviously relate to the engine mentioned by Dunn. There were thus at least two atmospheric engines erected in Northumberland before the momentous winning of Heaton began.

3.2 The Grand Alliance and the regulation of the vend

The impact of the atmospheric engine cannot be measured purely in terms of its technical contribution to coalmining. It caused organisational changes which were equally important. Its adoption increased the amount of capital investment needed in mining. Previously the initial

1. M. DUNN, op cit, p 23
2. NRO, MBE/V/1.
3. See Table 3

investment needed for the purchase of equipment, assembly of a labour force and the 'winning' of the mine before coal production had commenced and the enterprise had begun to support itself, was not great. It could be provided by individual landowners or partnerships of the gentry. The deeper and more complex winnings which the atmospheric engine made possible, as well as the remoter collieries employing elaborate waggonways, required a much larger initial capital input. The scope for small-scale entrepreneurship was reduced and the trend towards larger, more powerful combinations of capitalists, which culminated later in the century in the formation of embryonic coal companies was begun.

The most significant manifestation of this in the first half of the eighteenth century was the formation of the 'Grand Alliance'. Signed in 1726, this co-partnership was formed among three of the most powerful coal and land owning families in north England, the Liddells, lords of Ravensworth, the Wortleys, Lords Wharncliffe, and the Bowes family, earls of Strathmore. The agreement [1] was much criticized by anti-monopolists since it placed a large part of the responsibility for supplying the capital's fuel in the hands of a small and self-interested clique. The Grand Allies were soon able to secure leases of some of the most valuable coal-bearing property in Britain. They controlled, at one time, fifty-nine per cent of the coal producing capacity of the Tyne [2]. Although their motives were probably selfish, the Grand Allies may have had at least one generally beneficial effect. They recognised

1. NEIMME, shelf 18, a copy of the agreement. In fact the partnership had been in existence for a few decades, at least, (see Table 4) and the signing of the agreement was probably a legal formality.
2. See Table 5.

the need for a regulation of the coal-trade, a need which during previous times of competition and overproduction had become painfully apparent [1]. The concept of 'regulation' had a profound influence on the development of the coal-trade throughout the eighteenth and early nineteenth centuries. More than a century after the signing of the Grand Alliance, when a parliamentary select committee reported on the state of the industry, it had this to say about regulation:

> an agreement which from time to time has been entered into by the Coal Owners of the River Tyne and on the River Wear regulating the proportions in which they shall respectively supply the London and coasting markets during the year ... a quantity calculated on the vend of the preceding years is assumed as the quantity that may be required by the different markets and is divided between the two rivers.
>
> ... the actual quantity to be vended on each river is fixed once a fortnight, according to the demand, and distributes itself among the respective collieries on each river according to their proportions ... every coal-owner delivers in the price at which he engages to sell his coal during the year.
>
> ... it appears that during the existence of these regulations there has not been at any time a deficiency of supply experienced in the London Market, the number of vessels laden with coal being constantly in the pool beyond the natural vend; but it has been admitted that in arranging the amount of the supply, and fixing the price there is no other limitation than what will arise from the fear of competition from the collieries which may be opened on the Tyne and Wear district and from the collieries in the County of Durham which ship their produce at Stockton and from Scotland, Yorkshire and Wales.

1. P.M. SWEEZY, 'Monopoly and Competition in the English Coal Trade, 1550-1850', Harvard Economic Studies, vol LXIII (1938)

TABLE 5 : Quantities allotted to various coal-owners according to the regulation of 1727

Owner	Quantity		% total vend
Sir Henry Liddell	80,000	chaldrons	26.6
Edward Wortley esq.	54,000	"	18.0
Richard Ridley esq.	46,000	"	15.3
George Bowes esq.	44,000	"	14.6
Lady Clavering	22,000	"	7.3
George Pitt esq.	17,000	"	5.6
Alderman Rudston	14,000	"	4.6
Mr Wilkinson	10,000	"	3.3
Matthew White esq.	8,000	"	2.7
Mr Simpson	6,000	"	2.0
	301,000		

Source: NEIMME, shelf 18, Grand Allies Minute Book.

> The establishment of this regulation has been justified on two grounds; first, as being one which prevents the mischief which would, it is alleged arise to themselves from a competition among all the coal-owners on the Rivers Tyne and Wear; and secondly, to the public, from the limitation of supply. It is stated that with the same extent of machinery the collieries on the Tyne are capable of working double the quantity ... on what is now worked; ... an unregulated competition among the collieries would end in an entire ruin of those which are worked at the greatest expense. The difference between the expense of working the collieries is stated to be very considerable ... between sixteen or seventeen shillings to twenty-three shillings. The effect of the regulation in question is to raise the price of coal so as to enable the collieries which work at the greatest expense to work at a remunerating price, while they who can work their collieries at a less expense, and could therefore by underselling the others get possession of the whole market, exercise a politic forebearance, by entering into an agreement which secures them a greater profit on a more limited vend. It is also stated that if ... the inferior collieries were ruined and expelled from the trade the supply would then be entirely in the hands of a few large capitalists, who would be able to enhance the price and control the market to an infinitely greater extent than can now be accomplished ...[1].

Here the case in favour of regulation is elaborately explained, although the system had, by this time, achieved a much greater refinement than it had in the early eighteenth century. It was treated, especially in London, with a great deal of suspicion throughout its long history. Undoubtedly it kept the price of coal at an artificially high level, but not necessarily higher than it might have

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1. <u>Select Committee on the state of the coal trade</u> ..., <u>Parliamentary Report</u> (1830), pp x-xii

been had a more monopolistic situation developed after unrestricted competition. Moreover, the fact that it led to a high degree of co-operation among the coal-owners brought some stability to the industry, created a climate in which its development could be planned more effectively and, perhaps to some extent, safeguarded London's fuel supply.

Initially, the Grand Alliance produced a partnership with very large resources of capital to draw on. So difficult and expensive did the first applications of steam power to the task of mine-drainage prove, it seems possible that without the security and backing of those reserves of finance the initial experiments might have been seen to be such complete and costly failures that the acceptance of the new and vital innovation might have been seriously retarded. The winning of Heaton Colliery between 1725-7 represents the beginning of deep-mining in Northumberland [1]. It was one of the first great joint ventures attempted by the Grand Allies and required a scale and sophistication of engineering achievement which, at that time, was probably unmatched. From the outset the scheme was plagued with problems as the proprietors themselves pointed out:

> Further we have also ... several years ago, as you well know, taken to farm Heaton Colliery and have actually paid above twenty-four hundred pounds reserved rent and have been at the expense of a Chancery suit to settle one of the leases with Robert Midford which is not yet ended. And we have been at a very great charge in endeavouring to get wayleave to the River Tyne for the said Heaton Colliery, also in endeavouring to win the same ... upon the assurances you gave us of the great things you were able to do with your fire engines ...

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1. See Figure 33.

> and we are now and have long been at a full stand for want of that assistance you ought to give us ...[1].

The winning of Heaton Colliery represented the first investment of the Grand Alliance north of the Tyne. It was intended to be the first of many, for the 'Partnership', as the Grand Allies were collectively known, set about securing leases of large tracts of coal-bearing property there. Even by 1727 the list of collieries in Northumberland over which they exercised some control is impressive:

> Denton, Kenton, Brunton and Newbiggin
> Fenham and Newbottle Moor
> The remainder of Heaton and Gosforth
> Longbenton, Killingworth Moor and enclosures
> Chirton and grounds, north and east [2].

That the plans which accompanied these leases were ambitious is evidenced by notes in the Grand Allies Minute Book:

> Denton, Kenton, Newbiggin and Brunton might be won through Denton (wch. would be ye properest way to win, there being a good quantity of coals to be wrought in ye way ...). That part of Kenton as well as Brunton on ye south side of Wolsington or Ouseburn and all that is to work in Newbiggin might be led through Kenton and Benwell or Kenton and Denton to Tyne but better to Ouseburn mouth or Skinnerburn mouth. That part of Brunton north of Wolsington will have nothing of value in it, but what lies too deep except ye pt. that joins to Killingworth and north Gosforth [3].

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1. E. HUGHES, op cit, p 40
2. NEIMME, shelf 18, Grand Allies Minute Book, p 33
3. Ibid., p 37

The strong monopolistic tendencies which were partly the inspiration behind the Alliance are revealed here. With great perception, the Partnership had obtained the mining rights for most of the property in south-east Northumberland which, at that time, appeared to contain workable coal. That they never achieved an outright monopoly was mainly due to their failure to foresee how technology would bring large tracts of deeper coal, notably in the Wallsend Basin, within the ambit of economical working; "That part of Brunton will have nothing of value in it, but what lies too deep ..." Herein lies the basic misconception. What lay "too deep" in 1727 was not necessarily too deep thirty years later. In fact the Alliance did not manage to increase its share of productive capacity beyond what it had secured in 1727. A decade or so later thirty-six collieries were listed on the Tyne and the Grand Allies controlled only thirteen of them [1].

Figure 17 shows the spatial pattern of coal production in Northumberland in 1732. Capacity had moved from the west to the east of Newcastle in a most remarkable way. The old collieries north of the Tyne and above Newcastle Bridge, their shallower seams ravished by a century of intensive activity, had declined although Elswick maintained a sporadic output until the early 1730s. That the coal-owners had achieved a degree of corporate planning by this time is shown by the way in which the decision to cease working at Elswick was reached:

> Stella and Elswick as they are unprofitable collieries, to lay them in, and give to ye owners 800 tens that will lead them as much profit ...[2].

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1. See Tables 5 and 7.
2. NEIMME, shelf 18, Grand Allies Minute Book, p 32

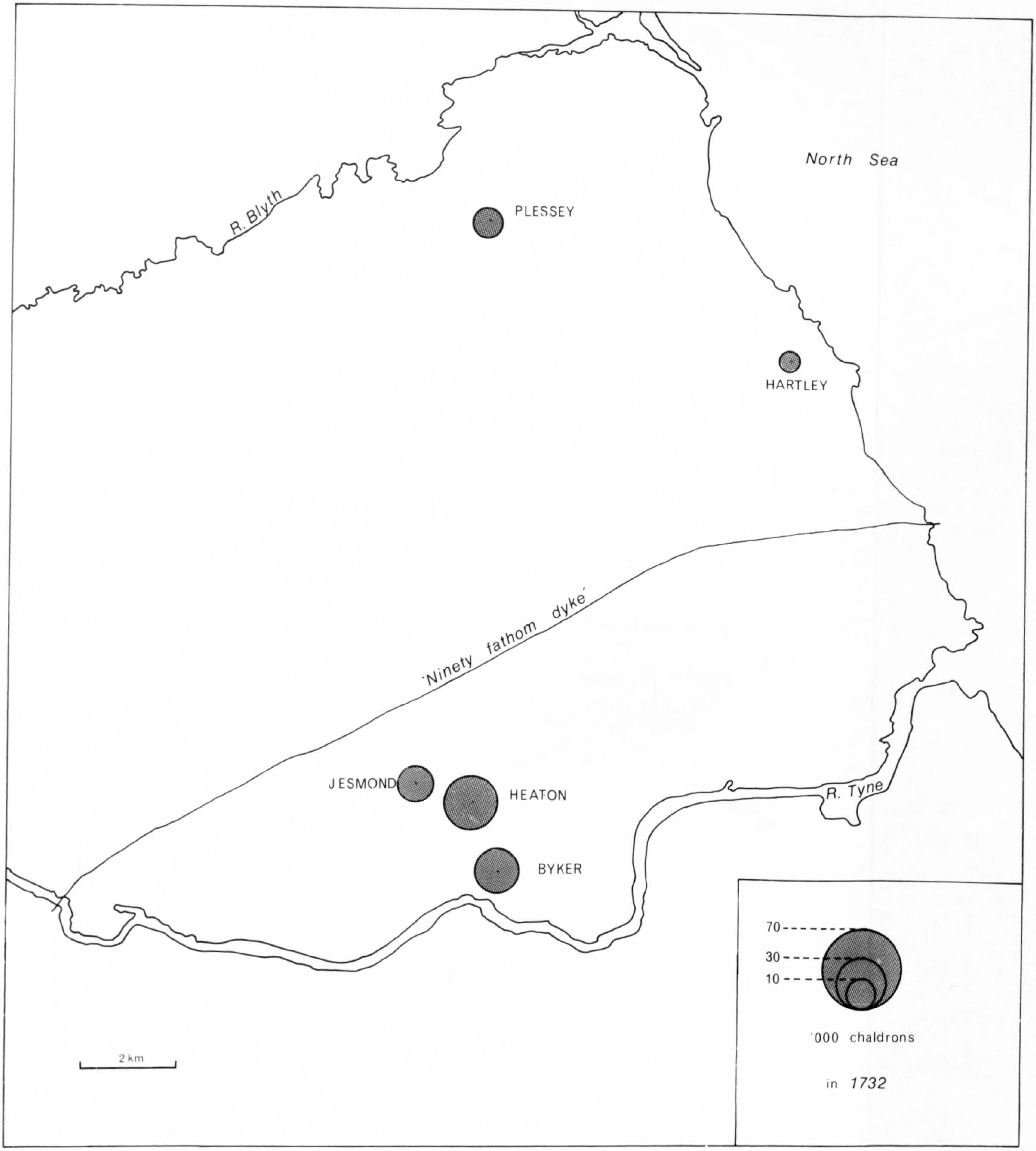

Figure 17 : The distribution of coalmining in 1732

The strictly laissez-faire mechanism by which economic viability, production or closure, was determined by profitability in competition had been undermined by regulation and the new ethos which it entailed. Comparative cost was no longer the only criterion. Instead each owner was allotted a proportion of the trade and he could supply that proportion in whichever way he wished, given the good-will of the coal-owners as a corporate body. Obviously productivity would continue to loom large in decision-making but regulation was already beginning to protect the weaker collieries from the worst ravages of competition.

In the valley of the Ouseburn new technology, initially harnessing water power, later using the atmospheric engine, had enabled three large collieries to emerge at Heaton, Byker and Jesmond. Within the context of the Tyne coal industry as a whole, however, mining in Northumberland had once more been overwhelmingly overshadowed by developments south of the river. In the first half of the eighteenth century a great phase of waggonway construction was enacted there. A comparison of Tables 6 and 7 reveals the extent to which the arena of sea-coal exploitation expanded in north-west Durham. New collieries with hauls of up to fifteen kilometres to staith entered the coal trade. Considerable and little-known feats of engineering, such as the building of the Tanfield Arch, were achieved and techniques of railway construction were steadily improved. The groundwork for the momentous progress in railway development, which was to take place on this coalfield at the beginning of the next century was even then being laid.

Why was there no parallel development north of the Tyne? The answer lies in the geology of the coalfield and, especially, in the role of the so-called Ninety Fathom Dyke. This tectonic fault runs in a north-

TABLE 6 : Collieries on the Tyne in 1724

Colliery	Owner	Distance from staith in miles	(km)
Elswick (Northumberland	Mr Wortley	½	1
Byker (Northumberland)	Richard Ridley	½	1
Jesmond (Northumberland)	Matthew White	1	1.5
Gateshead Fell (Durham)	Walter Blackett	2	3
Stella Grand Lease (Durham)	Sir Henry Liddell	2	3
Brockwell (Durham)	Mr Silvertop	2½	4
Ravensworth (Durham)	Sir Henry Liddell	3	5
Eighton (Durham)	"	3	5
Burdon Moor (Durham)	"	3½	5.5
Whorlton Moor (Northumberland)	Richard Peck	4	6.5
North Banks (Durham)	George Bowes	4	6.5
North Birkley (Durham)	Alderman Rudston	4½	7
Chopwell (Durham)	Mr Reed	4½	7
Burnhopefield (Durham)	Richard Ridley	5	8
Bryan's Leap (Durham)	Lady Clavering	5	8
Tanfield Moor (Durham)	George Pitts	5	8
Bucksnook (Durham)	Mr Bell	6½	10.5
Eweshurst Head (Durham)	Lady Clavering	7	11
	Total distance	63¼	101.5

Source: NEIMME, shelf 18, Richard Peck's View Book.

TABLE 7 : Collieries on the Tyne in 1738

Colliery	Owner	Distance from staith in miles	(km)
Byker (Northumberland)	Matthew Ridley	$\frac{3}{4}$	1
Low Felling (Durham)	Ralph Brandling	1	1.5
Jesmond (Northumberland)	Matthew White & Matthew Ridley	2	3
Gateshead Fell (Durham)	Mr Bell	2	3
Lands (Durham)	Mr Silvertop	2	3
Gelsfield (Durham)	John Robison	$2\frac{1}{4}$	3.5
Heaton (Northumberland)	Grand Alliance	3	5
Brockwell (Durham)	Mr Silvertop	3	5
Ravensworth (Durham)	Sir Henry Liddell	$3\frac{3}{4}$	6
Newbiggin (Northumberland)	Richard Peck	4	6.5
Whorlton Moor (Northumberland)	"	4	6.5
Eighton (Durham)	Sir Henry Liddell	4	6.5
North Banks (Durham)	George Bowes	4	6.5
Burdon Moor (Durham)	Grand Allies	$4\frac{1}{2}$	7
Prudhoe Moor (Durham)	Mr Humble	$4\frac{1}{2}$	7
Busty Bank (Durham)	Matthew Ridley	$4\frac{3}{4}$	7.5
Burnhopefield (Durham)	Matthew Ridley	5	8
Bryan's Leap (Durham)	Lord Windsor	5	8
Barker's Close (Durham)	"	5	8
Hagg (Durham)	Mr Humble	5	8
Andrew's House (Durham)	Sir James Clavering	$5\frac{1}{4}$	8.5
Tanfield Moor (Durham)	George Pitts	$5\frac{1}{2}$	9
Beckley (Durham)	Sir James Clavering	$5\frac{1}{2}$	9
Beamish (Durham)	Grand Allies	$5\frac{1}{2}$	9
Park Head (Durham)	"	$5\frac{1}{2}$	9
Dawson's Tanfield (Durham)	"	$6\frac{1}{2}$	10.5
Davison's Tanfield (Durham)	"	$6\frac{3}{4}$	11
Dean's Close (Durham)	"	$6\frac{3}{4}$	11
Bucksnook (Durham)	John Robison	7	11
Shield Row (Durham)	Grand Allies	$7\frac{1}{2}$	12
Beamish South Moor (Durham)	"	8	13
Lanchester Moor (Durham)	"	8	13

Pontop (Durham)	Lord Windsor	8	13
Collierly (Durham)	" "	8	13
Bushblades (Durham)	Matthew Ridley	8	13
Greencroft (Durham)	Sir James Clavering	9½	15.5
	Total distance	185¾ miles	291 km

east to south-west direction from the sea, two miles north of Tynemouth, and crosses the Tyne at Newburn [1]. The coal-measures are, in effect, displaced downward by up to 550 feet on its northward side. Before the nineteenth century it had the effect of rendering the seams on that side below the level of technological accessibility. The effect of the Great Downcast Dyke, as it was alternatively called, was more apparent than real, however, since the overall pattern of accessibility was more generally dictated by the synclinal attitude of the coal measures. Between Tyne and Blyth the geological topography was trough-like, the seams dipping from outcrops along the coast and up to twenty miles inland to depths of six to seven hundred feet (in the case of the High Main Seam) below sea level at the centre of the Wallsend Coal Basin. Overall it was this configuration which dictated accessibility. However, this influence was pervasive while that of the Great Downcast was sudden and catastrophic. In some collieries seams suddenly disappeared as the miners worked northwards, and could not be located again by drifting. Such discoveries could, and did, mean ruination for investors and unemployment for miners. In the days when the geology of the coalfield was but dimly understood the unexplored area to the north of the Ninety Fathom Dyke seemed as impenetrable as the jungles of Africa.

Unlike north-west Durham, better overland transport could not have the effect of bringing into production large areas of the Northumberland Coalfield. The coal was too deep and the knowledge and techniques for winning it had not yet been developed. The geography of the industry south of the Tyne was revolutionised by easier surface haulage in the form of the wooden railway. North of the Tyne this technique alone could not achieve similar results. More than half a century would

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1. See Figure 8

elapse before better extraction techniques combined with the new railway to enable such a geographical diffusion of activity to take place in Northumberland. Meanwhile, despite the small-scale developments which were continuing along the outcrops, in the east at Hartley and Plessey, in the west under the guidance of Richard Peck at Whorleton Moor and Newbiggin, the focus for the industry on north Tyneside remained firmly fixed in the Ouseburn Valley.

3.3 The rise and decline of the Ouseburn collieries

By 1735 there were at least eight atmospheric engines at work in the Ouseburn Valley. Byker and Jesmond each had two, and Heaton four [1]. This represented a prodigious investment. In 1733 Heaton vended 33,375 chaldrons of sea-coal, Byker 24,461 and Jesmond 16,304 [2]. Collectively this represented about 27 per cent of the total Tyne vend and virtually the whole of Northumberland's contribution to it. As a coal-producing district the Ouseburn Valley was only overshadowed at this time by the Tanfield area which contributed about 40 per cent of the vend. In the Tanfield area, however, the pits were shallower and relied on long waggonways. The Ouseburn Valley was in the vanguard of progress towards deep mining. At Heaton some of the pits were reaching depths of 400 feet (120 metres) and more below the surface.

Unfortunately the winning of Heaton was especially problematical. Only the resources of a partnership such as the Grand Alliance could have sustained it through the early financial failures. Retrospectively, at an inquiry into its eventual demise, Nicholas Walton emphasises this fact:

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1. NEIMME, Watson Coll., 10/43, f 2
2. NEIMME, shelf 18, Grand Allies Minute Book, pp 82-3

> this deponent can and does with great certainty say that the colliery was prosecuted with the utmost vigour, the produce therefrom did not in any one year exceed the year's outlay till after the end of the year 1731 at the end of which the sd. lessees were in disburse upwards of £30,000 besides interest thereupon. And so far was this colliery from working with success that he, this deponent, very well knows the sd. Sir Henry Liddell was never reimbursed his share thereof with interest by his share of the profits made in the several succeeding years ... [1].

Pushing back the frontiers of technical feasibility was evidently costly and not necessarily profitable. With regulation, however, it was possible for an innovating colliery experiencing difficulties to be supported by other collieries, the winning and working of which involved less technical risk. Only in this way could the progress of technology be facilitated and a future for the industry be guaranteed. In the absence of formal industrial research and in an industry where technical improvement was essential, new methods had to be successful. The innovating collieries which were working near to the limits of technical possibility had to be subsidised, to some extent, by others.

Byker, Jesmond and Heaton remained the three most important collieries in Northumberland for the two decades up to 1745. In 1738 each colliery had four working coal-pits which yielded varying amounts according to the conditions prevailing underground. Jesmond appears to have been the most productive at this time with about 1,400 tens during the year. Byker was somewhat less productive with 1,000 tens and Heaton, encountering the drainage difficulties which presaged the eventual demise

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1. NEIMME, Watson Coll., 10/43, f 2

of all three collieries, yielded about half that amount [1].

But in the mid-1740s the Northumberland coal industry received a set-back, the nature and enormity of which could not then have been foreseen. In retrospect it represents, perhaps, the failure of a primitive technology to overcome the great natural forces with which it was struggling. The cause also lies, however, in the intrinsic risk of the unexpected which mining must face even today.

In two decades during which the threat of innundation was constant the coalminers of Heaton had achieved a considerable understanding of drainage problems and shown a remarkable resourcefulness in dealing with them:

> the principal of the great feeders of water which this colliery of Heaton is loaded with lie in several stratums of stone above the seam, which said several feeders of water it has been the constant practice to stop or frame by wooden dams in the several sinking shafts or pits in the sd. colliery to prevent the same from falling down into the waist of Heaton ... at the Thistle ... several very great feeders of water were met with which were framed up ... in which frames or dams were fixed several lead pipes or cocks which were opened and shut to let off or stop the sd. feeders of water at pleasure ...[2].

Obviously, a considerable degree of control over the drainage of the colliery had been achieved. The flow of water in the superincumbent strata was regulated and, therefore, its collection in the sumps at the bottoms of the shafts, from where it was pumped by the atmospheric engines, could, to some extent, be controlled. Despite this high level

1. NEIMME, T.E. Forster Coll., 49/4, pp 26, 29, 51, 66
2. NEIMME, Watson Coll., 10/43

of engineering sophistication, it appears that the capability and reliability of the atmospheric engine had been overestimated:

> Three of the said engines (at Heaton) were erected at Ewesburn near to Heaton Hall, and the fourth at the rise part of the colliery near to Cragg Hall and the bob engine was erected in the workings of the Knab Pit in order to win the coal under the Thistle Pit Dyke ... that the said engines being overpressured with water so that the dip part of the colliery was unavoidably drowned, it was resolved to alter the fire engines in order to preserve and keep the rise part of the colliery from being also drowned with water ... that such alteration was accordingly made by lessening the lift from 44 to 22 fathoms and whereby a great increased quantity of water was discharged and drawn by the said engines and all this to no effect ... sayth at this time when all possible means was used to keep down the water at Heaton there were two fire engines at work upon Jesmond Colliery adjoining ...[1].

The initial plan appears to have been too ambitious. Technological breakthroughs did not normally enable coalmining entrepreneurs to reap vast new harvests of cheap coal. Coalmining problems are immensely varied and complex and, especially in the eighteenth century when a true understanding of them was often incomplete, new methods had to be painstakingly adapted to solve each one individually. At Heaton the capability of the atmospheric engine for draining the colliery seems to have been overestimated by 100 per cent and the winning depth had to be cut by half when, in due course, the harsh realities of this exaggeration became evident.

It is only to be expected in a primitive industrial society that new

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1. NEIMME, Watson Coll., 10/43, f 2

technology will be adopted by a process of trial-and-error. This reduction in the scale of operations at Heaton merely represents the natural response of early technologists to an over-estimation of their powers. It does not explain the sudden drowning of the Ouseburn collieries in the mid-1740s. Such catastrophes can only be explained by the coincidence of a number of events and conditions. The feeble performance of the atmospheric engine was one factor. There were a number of others.

That the reception of water from the atmosphere on a given area of terrain determines variations in drainage requirements within a mine beneath that area was well understood by the eighteenth century. Seasonal fluctuations in pumping costs were easily perceived. Increases in the volume of water in the sumps could be correlated with wet weather. The way in which the flow and retention of water varied spatially underground was less well understood. Miners working forward at a coal-face frequently encountered 'feeders' of water which placed additional demands on the pumping engines. By the later eighteenth century viewers had learnt the advisability of having reserve pumping capacity and engines were seldom kept constantly at work. Even so it was always possible to encounter a feeder of such magnitude that the pumps were overwhelmed.

At Heaton another important factor appears to have been the proximity of the Ouseburn itself. At this stage, when mines were still relatively shallow, there were dangers attached to working beneath bodies of water on the surface of the earth. It was possible for mining subsidence to disturb the surface strata to such an extent that water from streams and rivers could percolate into mine workings. This seems to have occured at Heaton:

> And one particular feeder of water was met with supposed to come from a rivulet of water called Ewesburn as the same was observed to increase with floods ... That the walls having been wrought in both Heaton and Jesmond and other collieries to the west has greatly sucken the stratum of stone and frame dams in the several pits beforementioned and particularly ye stratum of stone under the sd. rivulet so as in many places the same is much rent and shaken to the surface whereby the water may ... communicate or pass into the said rents or shakes, that all the sd, several feeders of water now have and before the 1st May 1745 had a communication with the waists of Heaton and Jesmond ...[1].

An inexhaustable, unstoppable feeder of water, the Ouseburn itself, had permeated the workings of Heaton Colliery. Not surprisingly the pumping system was gradually overwhelmed:

> notwithstanding the assistance which the engines of Jesmond gave to the drawing of water of Heaton it would have required seven fire engines at least to have drawn the water of Heaton ... so great was the overpressure of water ...[2].

Moreover, the implications of this were not only fatal for Heaton Colliery. As is suggested above, the drainage of adjacent collieries in close proximity to each other was, to some extent, interdependent. This remained so despite the fact that large barriers of coal were left untouched between collieries in an attempt to insulate each from the fortunes of its neighbours. Nicholas Walton points out that such methods are only effective in stopping water

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1. NEIMME, Watson Coll., 10/43
2. Ibid.,

> where the stone and coale is of a close kind and the wastes of water of small weight or pressure; yet where the stone and coale and wastes of water (are) of great weight and pressure it is unpossible (sic) they should be effectual ... more particularly where the colliery has been wrought in the walls whereby the several stratums are unavoidably much rent and shaken ...[1].

Walton had few doubts about the hopelessness of Heaton's plight:

> this deponent further saith that were he the owner of the royalty of Heaton, in possession of wayleaves therefrom to the river Tyne, with steaths (sic) and all conveniences for vending of coales, and a fortune equal to the greatest of undertakings ... he would not engage in winning Heaton Colliery ...[2].

Jesmond did not survive Heaton by more than a few months. The termination of pumping by Heaton's four atmospheric engines obviously placed an unbearable burden on Jesmond's two. The position of Byker, to the south, although uncertain, was less immediately perilous since it was separated from the Heaton wastes by a fault called the Jane Dyke:

> the Jane Dyke ... has never been drifted through into Byker on the south side thereof, but that the same is a barrier between and prevents the water from communicating from the wastes of Heaton and Byker lying north of the Jane Dyke to the wastes of Byker ... if a communication was made into Byker waste south of the Jane Dyke it would be of very ill

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1. NEIMME, Watson Coll., 10/43
2. Ibid.,

> consequence ... such feeders of water would come from Heaton and the neighbouring collieries as would overcharge the fire engines at Byker to the destruction of that colliery ...[1].

Byker resisted its increasing reception of water for five years but in 1750 the working of the pillars in the Hagg and Bird Pits had to be abandoned and a report of that date describes Byker as

> so unavoidably overcharged with water that it is not possible by any means whatever to work one hundred tens of coals [2].

Although a year later the Speedwell Pit was still yielding 300 corves it, too, seems to have been living on borrowed time:

> as the water is day by day rising in the Engine shaft they think all coals that can possibly be got should be got in case any accident should happen which at present cannot be foreseen; but from the hazardous situation of the colliery may be expected every day. And we are well satisfied that the present working is to a very great loss to the undertaker ...[3].

Production at Byker dwindled to a negligible amount in 1752. Although Sir John Lawson sunk the Recovery Pit to 75 fathoms (104 metres) at Byker Hill, some distance from the Ouseburn,[4] five years later and maintained a small colliery within his royalty for some years, the coal industry in the lower Ouseburn had reached almost a complete nadir.

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1. NRO, Ridley Coll., ZRI/35/22, p 64
2. Newcastle Central Library, Colliery MSS, vol F, p 23.
3. NEIMME, T.E. Forster Coll., 49/4, p 158
4. Northumberland County History, vol XIII (1930), p 41

The syndrome of decline reveals much about the inherent hazard of coalmining. Three separate and independent collieries had been developed with the aid of a new innovation, pumps powered by atmospheric engines. But, as they penetrated deeper coal and probably in an unconscious and undeliberate way, the three had developed a peculiar interdependence with regard to drainage. The danger of this interdependence was fully realised when the drainage system of one of the three was overwhelmed and the other two, in turn, succumbed to rising water.

The winning of Longbenton Colliery was a natural step in the progress of mining in the Ouseburn area, east of Newcastle, which followed logically from the earlier development of the royalties of Heaton and Jesmond. In 1735 the Grand Allies, undaunted by the difficulties they were encountering nearby at Heaton, had taken a 99-year lease of Longbenton Colliery from the Earl of Carlisle. The lease was secured upon the payment of a Certain Rent, initially of £400 per annum, rising progressively to £900, despite the offer of an equal Certain Rent and a greater tentale from Lord Morpeth on a 25-year lease [1]. The Allies had paid £3,600 in rent before the first coal was drawn at Longbenton. The winning began in 1744 with the sinking of the First Pit to the High Main Seam at 50 fathoms (91 metres) and in 1744 84 tens and three waggonloads were drawn from the new pit.[2]. In that year the total cost of winning was estimated at £6,315. In other words the Grand Allies had disbursed some £10,000 before they sold the first coal from Longbenton - some indication of the reserves of capital which colliery proprietors needed to have at their disposal.

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1. NEIMME, Watson Coll., 10/51, ff 2-6
2. NEIMME, Watson Coll., 10/54 ff 12-3

But by 1746 it seemed that the disaster which was unfolding lower down the Ouseburn Valley would spread, like some creeping palsy, to Longbenton too. In April of that year an impressive committee of viewers - Amos Barnes, William Dryden, John Leaton, William Newton, Thomas Rawlings, Ralph Unthank and Nicholas Walton - representing the best in mining expertise, gathered at Longbenton to consider the deteriorating position of the colliery.

> We ... find great feeders of water issuing from the roof in the waste in the west part of the Second Pit's workings, 140 yards from Heaton Boundary, which we apprehend come from the waste of Heaton and Jesmond Collieries, and from Ouseburn, and it is our opinion these feeders will increase in proportion to the rising of the water in Heaton and Jesmond wastes so as to overpower the present fire engine ...[1].

At this point the outlook was certainly grim but the viewers had a constructive course of action to suggest. In effect, they planned that the colliery should be compartmentalised with the Second and Third Pits being separated by strong frame dams from the Engine Pit's workings, almost as a modern ship is divided into sealed compartments to guard against innundation from below the water-line. It was a useful plan and in important principle. If innundation threatened only a part of the colliery needed to be lost. A breathing-space could at least be obtained during which additional pumping capacity could be installed. Nevertheless the unknown element of how strong the frame dams needed to be to withstand the increasing pressure of water upon them remained. Nor was there any accurate means of measuring the weight of water. The consequences of sudden innundation, more likely to occur where

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1. NRO, Ridley Coll., ZRI/35/22, p 68

water was being deliberately held back under pressure, were almost too terrible to contemplate. All that the viewers had to aid them in making such crucial decisions was their own experience and practical logic. In the event, they could only reach a hazy and non-commital conclusion as to the probable outcome of the measures to be adopted:

> in regard to what further quantity of water may communicate from the above wastes it is very uncertain, but as the water has about 6½ fathoms to rise to Tyne Level, and 4 fathoms more to Ouseburn level at Heaton Low Engine, it will certainly very much increase and we doubt the engine now erecting, with that going, will not be sufficient and ... all, or the greatest part, of the feeders of Heaton and Jesmond Collieries will communicate to Longbenton ... the leaving of a strong barrier will be the best security against it ...[1].

It appears that the frame dams combined with the barriers of coal which were left in situ between the collieries held back the water for some time, but on February 13th, 1749, almost three years after the meeting cited above another gathering of viewers observed in the Second Pit's workings "great feeders of water issuing from the roofs thereof in several places" [2]. The southern part of Longbenton Colliery was plagued by flooding problems throughout the ten years or so that the colliery operated. The quality of Longbenton coal, which became renowned on the London Market, and the technical experience which had already been gained at Heaton, Jesmond and Byker helped to stave off an earlier cessation of working there.

The final closure of Longbenton marked the end of an important phase

1. NRO, Ridley Coll., ZRI/35/22, p 68
2. NEIMME, Watson Coll., 8/4, p 155

both in the development of the coal industry in Northumberland and in the evolution of man's techniques of mineral extraction. The colonisation of the High Main Seam in the Ouseburn Valley had proved a formidable test of the determination and ingenuity of coalminers. Nevertheless, despite the financial losses, the stoppages and the setbacks vast quantities of coal had been extracted. For example some 14,885 tens (perhaps 722,000 tonnes) were led from the various pits at Longbenton between 1744 and 1753 [1]. Furthermore, a number of important steps had been taken which, at the time, probably passed unnoticed but which were, in retrospect, momentous in the progress of industrial man. It was in the Ouseburn Valley, between 1720 and 1750 that, for the first time, significant quantities of coal were won from beneath sea-level (or Tyne Level as the coal-viewers in Northumberland conceived it) and with the need for constant, large-scale pumping operations. More fundamentally, it was here that the effectiveness and flexibility of inanimate power in the form of the atmospheric engine, never before utilised on this scale, was proven in practice.

Although the geographical focus of mining operations in Northumberland remained, for three decades after 1725, the royalties immediately to the east of Newcastle, there were some significant developments elsewhere. The influence of geology, especially as it affected the depth and attitude of the High Main Seam, remained the dominant factor determining the overall pattern of coalmining. The High Main was the richest prize and because of the synclinal attitude of the strata, dipping towards the centre of the Wallsend Basin, the movement of operations was basically centripetal. The switch in importance from the 'above bridge' collieries

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1. NEIMME, Watson Coll., 10/54, f 36

west of Newcastle to the Ouseburn was the main facet of this in the west. On the eastern edge of the basin, however, a complementary motion was also occurring. The early pits in the vicinity of Tynemouth were long since exhausted but Chirton Colliery had been rejuvenated, initially by the Grand Allies. As early as 1727 they had observed that the colliery

> might be easily won by carrying up a level from ye west end of Shields for about 500 yards which will take off about 14 fathoms and ye water will be to draw about 14 more ...[1].

Unfortunately, ease of mining was inhibited in the east by local geological conditions to a rather greater extent than in the west and, also, the quality of coal was generally poorer there. Faults, volcanic intrusions and even quicksands presented many problems. Nevertheless sometime after 1740 a winning was made and the scale of operations was intensified after 1755 when John Watson became viewer of the colliery [2]. In addition, on the nearby royalty called Shiremoor a series of winnings took place between the Ninety Fathom and Chirton Dykes.

North of the Ninety Fathom Dyke Plessey, which had shipped its coal from the Blyth independent of the Tyne for a quarter century, was in trouble. In 1751 a committee of viewers reported the Venture Pit

> but in an indifferent condition ... we sent for all the workmen to hear their opinions and they all with a general consent would neither go to work the whole coal nor venture themselves to make up the pillars [3].

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1. NEIMME, shelf 18, Grand Allies Minute Book, p 33
2. NEIMME, Watson Coll., 9/18
3. NEIMME, T.E. Forstër Coll., 49/4, p 149

On the other hand, Hartley, in a similar location, was about to enter its greatest phase of expansion [1].

Like Hartley and Plessey in the north, there were some peripheral winnings in the zone of outcropping on the western rim of the coal-field. Wylam, Throckley, West Denton, Fenham and Kenton were the royalties thus involved in the first half of the eighteenth century. They were mainly concerned with the exploitation of seams lying below the High Main in the succession of seams (especially the Yard, Metal, Stone Coal, Bensham and Five Quarter Seams) which lay at shallow depth in the area and could be won inexpensively. Such coal was normally of inferior quality but could be readily sold for industrial purposes or to the coastal and London markets in time of dearth or rising prices. Moreover the industrial demand for coal was expanding rapidly, both locally and elsewhere, despite the decline of the sea-salt industry which had nurtured the growth of the pan-coal collieries in the seventeenth century. The growth of demand from metal-working, glass and pottery manufacture, and chemicals was more than compensating for dwindling sales of pan-coal [2].

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1. See my article appended.
2. N.R. ELLIOT,'Tyneside; a study in the development of an industrial seaport' <u>Tidjrift Econ.Soc.Geog.</u>, I (Nov.1962), II (Dec.1962)

CHAPTER FOUR

COLONISATION AND REVIVAL: 1760 to 1800

When Ord, Peareth and Reay began a winning of Walker Colliery in 1757 it probably seemed to contemporaries like just another colliery speculation. In retrospect, however, this winning was a great step forward in the development of the Great Northern Coalfield. By that time almost all of the most conveniently accessible High Main coal in Northumberland had been won. The only remaining extensive tracts lay at greater depth towards the centre of the Wallsend Coal Basin or north of the Ninety Fathom Dyke and, consequently, beyond the reach of the technology available at that time. The result was that thereafter winnings became more complex while a new spate of innovations and improvements enlarged the spatial scope of mining methods. In 1769 Smeaton increased the duty of the atmospheric engine, expressed here as the number of pounds of water raised one foot by the expenditure of a bushel of coal, from 5,590,000 to 9,450,000 and in 1776 the great step forward into the age of steam power was taken when Watt incorporated the condenser and expanded the potential duty to 21,600,000 pounds [1]. At the end of the eighteenth century Percy Main Colliery was raising thirty times as much water as coal [2]. Other innovations were equally important. The application of cast-iron, first to waggonway rails, then to underground tram-ways, and later to the making of wheels, increased the effectiveness of horse-power. But its usefulness in tubbing and damming, investigated on a number of occasions, was reduced by high rates of corrosion in hot damp mines. The adoption, firstly of the double-bucket water-wheel and, after 1790, of the Boulton and Watt

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1. W.S. JEVONS, <u>The Coal Question</u> (1865), pp 144-8
2. Ibid., p 71

steam-engine economised and speeded up the extraction of coal from deeper shafts. The introduction of coursing to ventilation facilitated the extension of underground workings. In 1804 it was estimated that the air of Hebburn Colliery travelled over thirty miles underground before ascending the upcast shaft [1].

4.1 The colonisation of the Wallsend Basin

In 1762 the West Engine Pit at Walker Colliery reached a depth of 600 feet under the supervision of William Brown, one of the most highly skilled of contemporary mining engineers [2]. It was a landmark which signified the beginning of the era of deep-mining. It is significant that the Walker winning was achieved without the assistance of any fundamentally new technique but simply by increasing the size of the machinery which had been in use for half a century or more. For instance, the main engine, although of the same basic design as most of the numerous atmospheric engines erected by Brown up to that time, had a cylinder diameter of 72 inches and was described as "the most noble and complete piece of ironwork" that had up to that time been produced at the famous Coalbrookdale foundry [3]. It was assisted by two smaller engines. Similarly the drawing apparatus employed eight horses per shift but was of the longstanding 'whim gin' design. It seems that innovation was provoked by deep-mining rather than the reverse. The demands of deep extraction soon highlighted the shortcomings of the old techniques and Walker became a focus for experimentation with new methods. In 1769 an atmospheric engine was applied rotatively to the drawing of coal there but was later superseded by a water-wheel. In 1784 Walker was the first colliery to successfully employ the Boulton

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1. W.S. JEVONS, op. cit., p 71
2. Northumberland County History, vol 13, p 44
3. Ibid.

and Watt engine for drawing purposes and it was the scene of Thomas Barnes' first attempt to use cast-iron cribbing. The success of Walker paved the way for the colonisation of the Wallsend Basin. Walker was the first in a series of large collieries on North Tyneside and was followed by winnings at Wallsend, Willington, Percy Main and Bigge's Main. By 1785 the Wallsend Basin had become the focus of the Tyneside coal industry with an output of 100,000 chaldrons (well over ¼ million tonnes) representing 22% of production on the Tyne. By the turn of the nineteenth century this amount had doubled.

In step with this great expansion of production, important changes in the control of the coal industry were also occurring. Table 8 gives the owners of each colliery on the Tyne and in Northumberland but many of these owners were not directly involved in coalmining. Some, it is true, maintained direct control over their collieries. In Northumberland the Blacketts, Brandlings, Delavals, Montagues and Ridleys - the established Tyneside landowning families - were notable in this respect. But others, including many who had possession of the larger, newer collieries, were content to play the safe and lucrative role of lessor, accepting the substantial rent which was due to them by virtue of that status while abdicating the risk of investment. This, however, allowed new blood to flow into the industry and may have had a beneficial and catalytic effect.

Any hopes of monopoly which the Grand Allies may still have nurtured had finally died with the drowning of Heaton, the 1738 parliamentary enquiry into the monopolistic behaviour of landowners and the exhaustion of Longbenton's best deposits. Although they remained important operators in their own royalties to the south, their interest north of the Tyne had diminished greatly by 1785 and many of the royalties which

TABLE 8 : Collieries in 1785

Colliery	Owner	Approximate Vend (in chaldrons)	Distance from staith in miles	(km)
Northumberland				
Blyth	M.W. Ridley esq.	12,000	5	8
Byker Hill	Sir John Lawson	10,000	1½	2.5
Callerton	Colonel Schulz	16,000	6	9.5
Greenwich Moor (Throckley)	Greenwich Hospital	14,000	5	8
Hartley	Lord Delaval	13,000	2	3
Killingworth Moor	Lord Carlisle	22,000	1½	2.5
Montague Main (West Denton)	Mrs Montague	24,000	1½	2.5
St Anthony's	Lewins and Hargrove	6,000	1½	2.5
Walbottle Moor	Duke of Northumberland	15,000	5	8
Walker	Corporation of Newcastle	29,000	1	1.5
Wallsend	Dean and Chapter of Durham	19,000	1	1.5
Willington	Ralph Milbanke esq.	30,000	2½	4
Wylam	John Blackett esq.	12,000	5	8
Durham				
Blaydon Main	Lord Montstuart & Partners	7,000	1	1.5
Bushblades	George Silvertop esq.	16,000	11	17.5
Felling	C. Brandling	16,000	1	1.5
Jarrow		10,000	1	1.5
Marley Hill	A.R. Bowes	8,000	4	6.5
Park Moor		12,000	3½	5.5
Pontop Pike	Lady Windsor and John Simpson esq.	30,000	11	17.5
Ravensworth	Sir Henry Liddel, bart.	26,000	3	5
Stanley	Grand Allies	30,000	12	19.5
Tanfield Moor	John Pitt	17,000	8	13
Whitfield	George Silvertop esq.	20,000	6	9.5

Source: Newcastle Central Library, Colliery MSS, vol F, p 71.

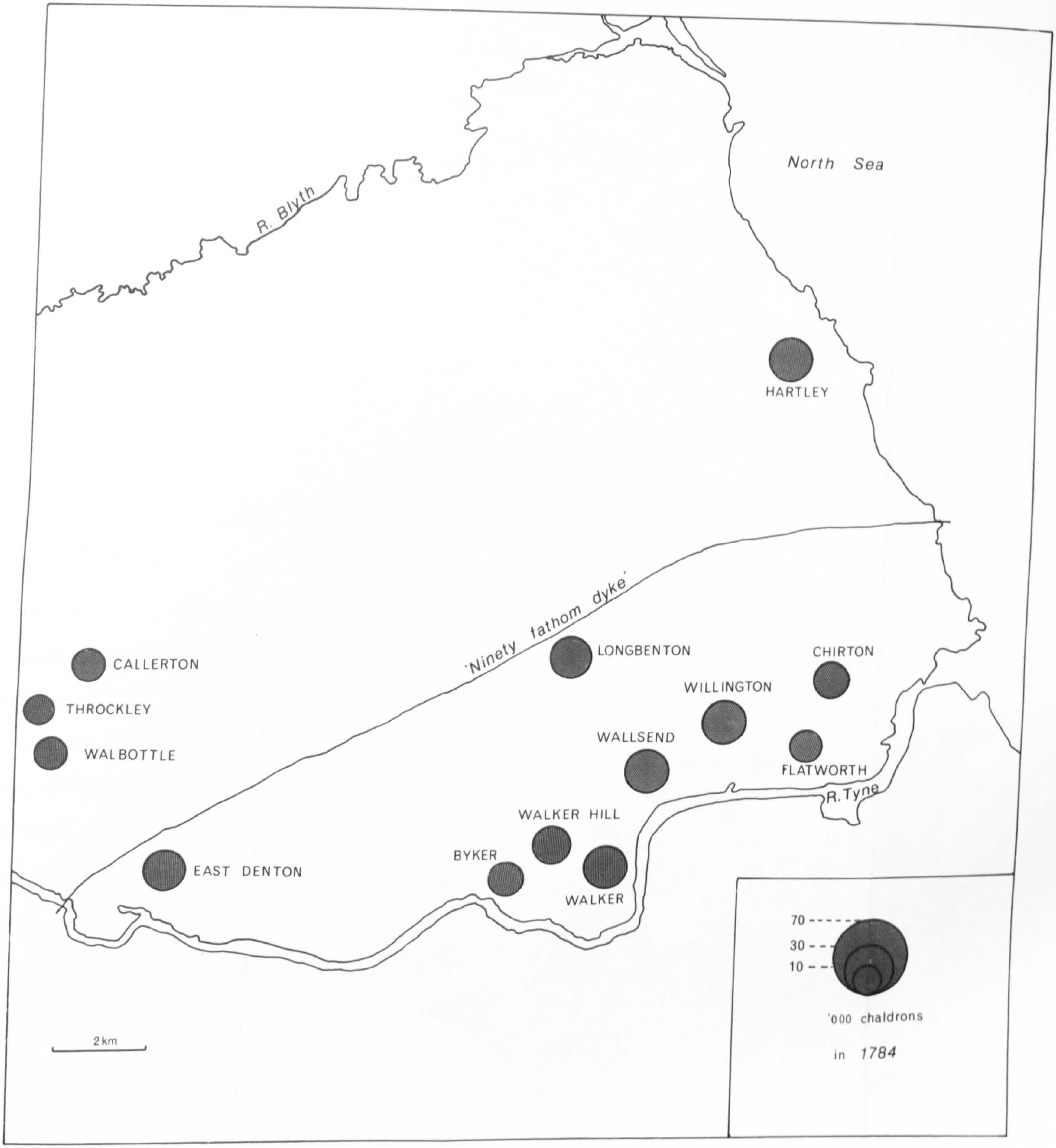

Figure 18 : The distribution of coalmining in 1784

they had controlled were re-leased. In their place a succession of varied partnerships of entrepreneurs and capitalists emerged, early embryos of the coal companies which were formalised in the next century and dominated the industry up to nationalisation. Ord, Peareth and Reay, who won Walker in 1757, were one such combination but more important was the partnership which came to be known as 'Bells and Brown'. It derived from an agreement between a family of property-owners and businessmen, the Bells, who provided the capital, and the successful mining engineer, William Brown, who provided the expertise and inspiration. Since it was Brown who had supervised the winning of Walker, it is hardly surprising that the new partnership would be instrumental in the colonisation of the Wallsend Basin.

Despite the fact that technical and managerial changes were ushering in a new period of deep mining, there was as yet little extension of operations into the remoter coalfield. North of the Tyne the big new collieries - Walker, Willington, Wallsend, Killingworth Moor and Montague Main - were all within three miles of staith. But some locational change was occurring. East of Newcastle there was a progressive, centripetal movement towards deeper coal. In the west there was a movement of outcrop winnings northwards, evidenced by the opening of Callerton, Throckley and Walbottle Moor collieries.

By 1785 the colonisation of the Wallsend Basin had tipped the scales in favour of Northumberland and the domination of the Tyneside coal industry which, Durham collieries had enjoyed for two hundred years since the signing of the Grand Lease, had come to an end. A few big new collieries had been opened in the Stanley and Pontop areas of north-west Durham. Significantly, however, the average distance from staith of the thirty-one collieries in Durham shipping coal from the Tyne in 1738, at

8.6 kilometres, was almost the same as that of the eleven collieries doing likewise in 1785. Clearly, the collieries with longer hauls were suffering in competition with those exploiting deeper reserves nearer to the river. The counter-balancing costs of extraction and haulage were constantly changing and tilting the relative advantage towards the distant collieries or towards the deep collieries. In the half century after 1738 there were no great improvements in waggonway transport while momentous strides had been made in techniques of deep extraction. That the collieries furthest from staith were vulnerable is suggested by a letter from Matthew White Ridley on a fall in the price of coal:

> this lowering ye price of coals gives an ugly propect (sic), such a one indeed as would absolutely prevent working those distant collieries if there was not a reasonable probability of the price advancing again to 13 shillings. I am now, for the reason just mentioned, obliged to let Bushblades, your neighbour, stand still better times ... [1].

In addition, the dislocation of waggonway transport as a result of bad weather conditions was normal in the winter months. Thus the advantage in cost and efficiency in the third quarter of the eighteenth century lay with the deep north Tyneside collieries. It would remain with them until the advent of the iron railway and the locomotive in the second decade of the next century.

In 1751 John Rawlings, the borer, discovered the High Main seam at 360 feet below the surface on Tynemouthshire Moor, "the same as that at Longbenton" [2]. Four years later Bells and Brown negotiated a

1. NRO, Ridley Coll., ZRI/35/15
2. NEIMME, T.E. Forster Coll., 49/4, p 199

seventeen year lease of Shiremoor Colliery. It was the first substantial speculation undertaken by the new partnership. In 1760 it was calculated that the profit on every ten of coal would be five pounds and sixpence. The vend would be a modest 1,200 tens per annum [1]. If all went well a decade would bring to the lessees over £60,000 in profit. Progress was slow because Shiremoor was a difficult colliery. It was not until 1767 that a comprehensive winning of the High Main was achieved with the aid of a large pumping engine designed by William Brown. Thereafter progress was rapid and in 1774, when the Orphan Pit was sunk, there were five pits working coal [2].

More significantly, in the previous year Bells and Brown had begun the winning of Willington Colliery, one of the most ambitious projects for mining coal yet to be undertaken. They had obtained from Ralph Milbanke a lease, to run for thirty-one years, of both the colliery and Willington and Balkwell farms. This practice was common since the number of horses employed by collieries had increased and fodder was a costly item of colliery expenditure. Coalmining and local farming already had a peculiar symbiosis. Not only did the collieries rely on the farms for the provision of hay but the growing colliery workforce provided a substantial market for dairy products and vegetables. The wealth created by coal had multiplier effects benefiting the whole local economy.

The returns exacted by Milbanke were extensive. In the first place Bells and Brown had to pay a 'certain rent' of £400, for which they could work 533 tens per annum. For every ten in excess of that they would have to pay a 'tentale rent' of fifteen shillings. Then, Milbanke took 'wayleave rent' of two shillings per ten for coal wrought by Bells and

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1. NEIMME, T.E. Forster Coll., 49/4, p 199
2. NEIMME, Johnson Coll., 4/4, p 37

Brown in adjacent royalties but led across Willington estate. Where such coal was drained by watercourse which passed through Willington a further two shillings 'watercourse rent' was due to the landowner. When coal from an adjoining royalty was drawn at one of the pits at Willington, Milbanke could take a 'shaft rent' of two shillings and sixpence per ten. In addition the rent which he received for Willington and Balkwell farms was £750 per annum [1]. Such were the rewards which nature had fortuitously bestowed upon the coalfield landowner.

Ralph Milbanke was not the only creditor ~~which~~ with whom Bells and Brown had to contend ~~with~~ in their quest for 'Wallsend' coal. In 1775 they agreed to pay the corporation of Newcastle a wayleave rent of £100 per annum for 800 tens and two shillings and sixpence per additional ten for coal led to staith across a narrow strip of land which was owned by that authority and which separated Willington from the Tyne. For 'staith room' (£24 per annum), watercourse rent (£20 per annum) and the lease of a small farm near the river for the pasturing of waggonway horses (£60 per annum) the Corporation would receive further reward [2]. In short, Bells and Brown needed to lay out some £1,404 in rent before the first penny of the huge sum which would be required to win the coal had been expended, and a number of years before the first returns from coal-working could be expected.

The sinking of the Engine Pit at Willington Colliery was begun in the autumn of 1773. In November of the following year it had reached 75 fathoms, a bob gin had been installed and pumping operations had begun. The task of sinking the shaft was sub-contracted to a team of 'sinkers' - a practice which was increasing with regard to many types

1. NEIMME, Watson Coll., 13/110
2. Ibid.

of colliery work - at a cost of eleven guineas per fathom [1]. This was another substantial item of expenditure incurred long before any profits from the colliery were forthcoming. In all well over one thousand fathoms (1,820 metres) of shaft would be sunk during the development of Willington Colliery.

By April 1774 the assembly of the workforce required for the new colliery was underway. Inter-colliery migration was by now part of the working class way of life on Tyneside. That this could pose problems of a human nature is borne out by George Johnson, one of the Willington viewers:

> The people that come to work at Willington from the Moor (Shiremoor) are not, nor will they be, under subordination, not even to myself. They will not do anything but as they please and seem determined to acknowledge no superior but Mr Hall who has also given an instance of intending to thwart the orders given at the new colliery in the affair of a banksman being ordered from the Moor to team water at the 3rd staple ... [2].

Labour disputes were increasing with the growing resistance of the coalfield workforce to open exploitation. On Tyneside the miners were eclipsed only by the keelmen in the development of protective unions [3].

On October 28th 1775 the High Main Seam was attained in the Engine Pit at Willington at a depth of well over 600 feet (182 metres) from the surface. By that time the sinking of two coal pits, the Milbanke and the Edward had begun [4]. Early in the following year the first corves

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1. NEIMME, Johnson Coll., 4/4, p 1-40
2. Ibid., p 7
3. D.J. ROWE, 'The Decline of the Tyneside Keelmen in the Nineteenth Century', <u>Northern History</u>, vol IV (1969)
4. Newcastle Central Library, Colliery MSS, vol F, pp 62-65.

of coal were raised up the new shaft [1]. It was not until 1777, however, that the Engine Pit was working at full capacity - raising about 1,600 corves per week. On the 27th April 1777 the smooth progress of the colliery came to an abrupt halt. One of the colliery viewers, George Johnson, described how

> a terrible accident happened at this colliery occasioned by the carelessness of the Engine man who had let the water get so high that the air courses were stopped up and on their setting fire to the sulphur pipe ... it took fire and blasted and destroyed the brattishes and air courses. Thirteen horses are lost and are yet underground [2].

Although no human lives were lost, repairing the engine shaft took six weeks.

Yet despite this set-back the progress and expansion of the colliery continued unabated. In 1778 Bells and Brown secured from Bewicke, Craster,Wilson and Lake a lease for 51 years of Longbenton Moor, one of the last large royalties where the High Main lay untouched. They also obtained a lease of the smaller royalty of East Benton. The necessary wayleave leases were duly concluded [3]. Interestingly, one of them indicates the landowner's growing awareness of how inflation could erode his advantage, especially where long leases were concerned. The lease which Charles William Bigge granted for coals from Longbenton passing over his estate at East Benton was divided into two periods of twenty-two years, with the rent rising substantially at the end of the first [4].

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1. NEIMME, Johnson Coll., 4/4, pp 54-7
2. Ibid., p 58
3. NEIMME, Watson Coll., 13/110
4. Ibid.

In 1784 Bells and Brown began the sinking of the Engine Pit, East Benton Colliery, and in the following year a coal pit was begun. By 1786 expenditure on this winning had reached £8,500 [1]. In the same year that this new winning commenced a costly project for winning the 'dip' coal at Willington Colliery was being considered. Bells and Brown asked for an

> Estimate for sinking the Edward Pit (a further 18 fathoms) in Willington Colliery and driving a stone drift to the full dip from there for the purpose of bringing the coal to the said pit either in boats or waggons [2].

Brown and his partners were obviously considering the possibility of underground water transport. This scheme was not as bizarre as appears. In an age when canals were revolutionising surface transport and before the use of wrought iron had improved the performance of rolley-ways, in theory at least, underground canals might be a logical extension of existing technology. One such canal was certainly built by John Smeaton to serve the Nenthead Lead Mines [3]. The computed cost of the Willington project was £1,606 and included "the building of 4 boats at £40 each" [4]. In the final event waggons on rails were preferred to boats on water at Willington, an early premonition of the eventual demise of British waterways.

All in all, it is clear that the enterprise was going well. In the

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1. NEIMME, Johnson Coll., 4/4, pp 77-103
2. Newcastle Central Library, Colliery MSS, vol F, p 65.
3. J. RAISTRICK and B. JENNINGS, <u>A History of Lead Mining in the Pennines</u>, London (1965), pp 151, 201.
4. Newcastle Central Library, Colliery MSS, vol F, p 65.

same year of 1784 the sinking of the Milbanke Pit at a projected cost of £2,020 was begun [1]. Willington was by this time the largest colliery in Northumberland and one of the largest on Tyneside [2]. Evidently, the scale and complexity of the Willington project, even in comparison with the similarly momentous scheme which was undertaken by the Grand Allies at Heaton half a century before, was considerable. Few men could have risked the financial resources, even fewer would have had the vision and knowledge to contemplate such an undertaking. This kind of industrial enterprise, because of its technical nature and scale, was becoming extremely exclusive. Mining engineers of the experience and talent of William Brown were few and far between. Because the northern coalfields were in the vanguard of mining development they became great exporters of innovation and advice [3].

The colonisation of the Wallsend Basin culminated in the winning of the Wallsend Royalty itself. This comprised a large estate owned by the Dean and Chapter of Durham. Chapman and Partners commenced operations in 1778 but the first sinking encountered a bed of quicksand and had to be abandoned. The lease was taken over in 1781 by a partnership known as Russell and Wade, of which William Russell appears to have been the guiding light [4]. This succeeded in sinking two shafts the 'A' and 'B' pits to the High Main Seam at 111 fathoms. In 1786 the 'C' and 'D' pits were commenced, an 'E' pit was opened seven years later and, in 1802, the 'F' pit completed the alphabetical sequence of success. Later the 'G' or Church Pit was sunk but this was a separate winning. Not surprisingly

1. NEIMME, Johnson Coll., 4/4, p. 62
2. See Table 8
3. The Buddle Collection, for instance, contains many views by John Buddle of collieries in other British coalfields and even outside the British Isles.
4. <u>Northumberland County History</u>, vol XIII, pp 47-8

a winning of this scale and depth encountered serious mining problems and Wallsend became notorious as a 'fiery' colliery. An explosion in 1785 necessitated the drowning of the 'B' pit and during the work of reopening it three separate explosions cost nine lives [1]. Between 1785 and 1838 two hundred lives were lost altogether due to explosions at Wallsend Colliery. Nevertheless in terms of profit and output the colliery was undoubtedly a success, at least until the High Main was exhausted in 1831. At the zenith of its fortunes it produced about 70,000 chaldrons annually, quite the largest colliery of the day [2].

With the success of Wallsend and Willington Collieries the colonisation of the Wallsend Basin was effectively completed. It was one of the great and unsung achievements of the Industrial Revolution. By 1804, of the twenty productive collieries in Northumberland the six largest were those of the Wallsend Basin. These, with a combined output of 254,698 chaldrons (about 652,000 tonnes), produced more than the other fourteen put together [3]. They also accounted for more than 40 per cent of the seasale coal leaving the Tyne. By then, the extent to which the Northumberland collieries had eclipsed those of south Tyneside was truly remarkable. For the regulation of 1816 the collieries were divided into two categories, first and second class, according to the size and quality of their produce. Of the nine collieries which came into the first category only two were south of the river [4]. The Wallsend Basin had become the focus of the industry in terms of both quality and quantity of produce.

4.2 The revival of the outcrop collieries

The list of collieries in south-east Northumberland in 1804 not only

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1. Northumberland County History, vol XIII, pp 47-8
2. NEIMME, Buddle Coll., vol 15, p 250
3. See Table 9
4. NRO, Coal Trade Minute Books, List 60, vol 2

TABLE 9 : Vend of coal from Northumberland collieries in 1804 (in chaldrons)

Colliery	Seasale	Riversale	Landsale	Total
Wallsend	60,132	818		60,950
Willington	40,362	2,040	854	43,256
Percy Main	36,652	3,348	1,471	41,471
Walker				37,663
Bigge's Main	36,075	782	360	37,217
Heaton	32,430	1,384	327	34,141
Benwell				31,238
Killingworth				30,000
Holywell & Walbottle	15,496	11,394	202	27,065
Benton	21,743	3,285	808	25,836
Hartley	15,986	4,613	958	21,557
East Kenton				17,475
Cowpen	16,393			16,483
Elswick				16,000
Plessey				13,000
Montague Main (East Denton)				12,771
Wylam				11,049
West Kenton	8,323	846	1,120	10,289
Murton	8,462	463	434	9,363
Baker's Main (West Denton)	3,528	270		3,798

Source: NRO, Coalmining Records, List B, vol I.

shows the pre-eminence of the large collieries of the Wallsend Basin but also reveals that a revival of coalmining west of Newcastle had taken place by then. Those above-bridge royalties, - Benwell, Elswick, Kenton, Denton (Montague Main and Baker's Main Collieries), and Newburn (Holywell and Walbottle Colliery) - which had been the scene of the early coalmining industry in Northumberland and which had declined and ceased working in the late seventeenth and early eighteenth centuries, had been rejuvenated by a spate of new winnings. The main reason behind this was a sudden acceleration in the growth of the seasale market as the momentum of industrialisation quickened in the second half of the eighteenth century [1].

The revival of the above-bridge collieries appears to have occurred first of all among the most distant ones on the very rim of the coalfield - Throckley, Walbottle, Callerton and West Denton. Only later, in the closing years of the century, did Benwell and Elswick reinforce the trend. With regard to the western royalties it is often difficult to differentiate periods of activity from periods of dormancy. Here the coal was so shallow, often outcropping at the surface, that a minimum of capital expenditure was required to make a winning. Some type of coal-working, be it only a single pit working a few fothers a day for the locality or perhaps Newcastle (this area was well placed to cart coal downhill into the city), was normally not far away. In contrast to the area east of Newcastle, mining in the west was more extensive than intensive. Winnings were smaller, shallower, involving less capital expenditure, and yearly output was less great. Consequently, coal reserves lasted longer, exhaustion came less suddenly, and because these collieries were not working as near to the limits of technical viability as the Wallsend

1. See figure 24

collieries the likelihood of complete disaster was diminished. They could whittle away steadily at the ample reserves of shallow, if rather poor, coal in the knowledge that other collieries were innovating and experimenting. This may be overstating the case since the Blacketts at Wylam, William Hedley at Throckley and Christopher Bedlington at Denton were later responsible for some notable innovations [1]. All collieries were different and had their own individual problems. Every pit was an innovation to some extent. Suffice it to say that, because the coal in these collieries was less deep, winnings tended to be less demanding technologically.

Throckley is an example of one of these western collieries. Originally both the colliery and the estate were owned by the Earl of Derwentwater. In the early years of the eighteenth century coal was won by means of 'bob gins' [2] and in 1714 a new winning at an estimated cost of £1,355 was being considered [3]. For his part in the Jacobite uprising of 1715 the Earl was attainted and executed and, as a result, the crown granted Throckley to Greenwich Hospital. Little evidence has come to light of activity at Throckley in the 1720s and 1730s but by 1752 a new winning on the south side of the Ninety Fathom Dyke on Throckley Fell (sometimes called Greenwich Moor) by William Brown had been completed [4]. A separate source [5] records that in the previous year a Tryal Pit was working the Engine Seam at 49 fathoms, an Industry Pit was also active and an atmospheric engine had been erected. The name of the former pit seems to suggest that at this stage the venture was still young. Throckley

1. These innovations were more concerned with haulage than deep winning.
2. PRO, MPII/40/25
3. NEIMME, shelf 18, Richard Peck's View Book, p 21
4. NEIMME, Johnson Coll., 4/3, p 110
5. NEIMME, T.E. Forster Coll., 49/4, pp 161-9

appears to have been the first colliery over which William Brown, in the infancy of his career, had control. Clearly a period of renewed activity at Throckley, possibly spurred on by the difficulties which the collieries east of Newcastle were experiencing in the later 1740s, had been initiated [1]. By 1759 the extent of working at Throckley is impressive as an account of coal resting at various pits and at the colliery staiths suggests [2].

It is clear that during the 1750s Throckley had become a productive colliery supplying 'seasale', 'landsale', and industrial (suggested by the stockpile of 'cinders' or coke) markets. In 1765 a further new winning was completed by Brown and the colliery, again, rejuvenated [3]. Compared with those of the Wallsend Basin, the colliery was modest in scale. In 1774 the vend of prime seasale coal (normally described as 'round' as opposed to 'small') was 15,527 chaldrons [4], a similar quantity to that of 1785 [5]. An indication of the size of the labour force required by such a colliery is given by particulars of binding at Throckley on October 29, 1774:

> We have bound 93 men and 42 lads and yesterday they cast lots for the pits now going, the number of men to each pit as follows, viz. Jane, 28; King, 20; Hope, 16; Hill, 20; Plain, 9. The lads will be set as occasion requires [6].

It is noteworthy that none of the pits which were active in 1759 had

1. See pp 115-22
2. See Table 10
3. <u>Northumberland County History</u>, vol XIII, p 35
4. NEIMME, Johnson Coll., 4/4, p 8
5. See Table 8
6. NEIMME, Johnson Coll., 4/4, p 6

TABLE 10 : Coal resting at Throckley Colliery, May 1759

	Seasale chaldrons	Landsale fothers
Street Pit		188
Matthew Pit		484
Spring Pit		138
Dayhole Pit	8	80
Fortune Pit	10	
Chance Pit		
Dyke Pit	6	
Goodluck Pit	2	
Thistle Pit	209	
At the cinder ovens, now cinders		35
At the Staith, covered	255	
uncovered	167	
	657	925

Source: NEIMME, T.E. Forster Coll., 49/4, p 183 survived as important producers up to 1774. Furthermore, a decade later, when viewers Walton and Turner reported on the state of Throckley Colliery [1], they listed eight pits (the Engine, the Maria, the Nymph, the Success, the Turlton, the Union, the Ward and the Xenia), none of which correspond to pits mentioned previously. Clearly, the pits of Throckley were unusually short-lived, a fact which further distinguishes the outcrop collieries on the rim of the coalfield from the deep collieries towards the centre of the Wallsend syncline.

Another distinguishing feature of the shallower outcrop collieries, which Throckley exemplifies, was the poor quality of their coal. Throckley was well outside the outcrop of the High Main and had only the lower seams in the succession at its disposal. In 1774 three seams were being worked there - the Engine (or Beaumont), the Main (or Denton Low Main) and the Splint (or Brockwell) Seams [2]. Since these seams were thinner and their coal was poorer in comparison with the High Main, there were marketing problems and the proportion of output which was 'merchantable' was smaller. As a result, Throckley had difficulty in getting rid of its abundance of residual 'small coal':

> The small coals made at this colliery increase to so great a height or quantity that from an account kept of late it appears a full fourth is left at the pits besides what is made at the staith, and few or none are vended, so that this evil reduces the profit of this colliery to a nothing, or next to it [3].

The London Market had become used to high quality coal. Some collieries

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1. NEIMME, Johnson Coll., 4/2, pp 27, 43
2. NEIMME, T.E. Forster Coll., 49/4, p 184. See Table 13
3. NEIMME, Johnson Coll., 4/4, p 2

could obviate the problem, as Walbottle did, by cultivating the 'landsale' and 'riversale' markets. The viewer of Throckley, in 1774, suggested:

> Would not 2 or 3 cynder ovens on our Burn Quays help the vend of our small coals a little if a trade could be made for them [1].

The final proviso was crucial. The competition for the limited local domestic and industrial market was increasing. Moreover, the chief industrial consumer of small coal, the sea-salt industry, had greatly declined by this time. In comparison with other collieries Throckley was remote from important centres of industrial and domestic coal consumption. Kenton, for example, was much better placed to supply the Newcastle market while Walbottle could move its small coal to the riverside industries around the Newcastle-Gateshead bridge-point by keel with ease. Marketing difficulties and the poor quality of its coal were probably at least partly responsible for the demise of Throckley Colliery by the end of the eighteenth century.

The locations of both Callerton and Walbottle collieries were very similar to that of Throckley, though Callerton was slightly more disadvantageously placed for access to navigable water. Callerton had been dormant for many decades when in 1776 William Cramlington took a 31-year lease from Colonel Schulz and began sinking an engine pit [2]. Subsequently some 41 pits were sunk to the same seams as were worked at Throckley [3]. At Walbottle "the first regular winning" was made by the

1. NEIMME, Johnson Coll., 4/4, p 2
2. Newcastle Central Library, Colliery MSS, vol A, p 53.
3. <u>Northumberland County History</u>, vol XIII, p 40

Duke of Northumberland in 1770 [1]. In 1776 the Engine was overpowered and "the pits and workings of both seams were filled with water from the adjacent workings of Throckley" [2]. Two alternatives for re-winning were examined - one by means of a Tyne level drift, the other by erecting an engine at Dewly Burn. The new winning was made in the uppermost seam by extending a drift which was formerly used by Throckley through Walbottle to Tyne level [3]. In 1778, only two years after the flooding, William Gibson optimistically observed

> As to the preparations for obtaining coal for 34 or 5 years there does not appear to be any doubt of it as the present Tyne level if carried properly on will, in all probability, lay coal dry to last much more than that time, provided the coal retains its goodness under the boggy grounds [4].

At any rate the coal thus won lasted until 1785 when the winning was extended after an engine had been erected at Dewley Burn [5].

By 1796, however, increasing feeders of water from Callerton Colliery waste had overpowered the engine and interrupted the working of Walbottle. A new pit called the Flora Pit was sunk in the extreme north of the royalty, as an expedient, and, in the following year a proposition was put forward

> for a more complete and effectual winning by a new level from Tyne ... to lower the water in the old waste lying

1. NEIMME, Buddle Coll., vol 6, pp 39-45
2. Ibid.
3. Newcastle Central Library, Colliery MSS, vol E, p 56
4. Ibid., p 58
5. NEIMME, Buddle Coll., vol 6, pp 44-45

between the river and Walbottle Dene winning ... [1]

The success of this venture helped to make Walbottle one of the largest collieries west of Newcastle in the early years of the nineteenth century.

Apart from the growth of coalmining where seams outcropped along the western rim of the coalfield, there was also a resurgence of activity in the old above-bridge collieries - Benwell, Elswick, Denton and Kenton - in the second half of the eighteenth century. These had provided the bulk of Northumberland coal in the seventeenth century but, for the most part, had declined in the face of increasing depth and drainage costs as upper seams had been worked out. The more sophisticated technics which became available after 1760 combined with the growth of the market brought the lower seams in these royalties within the scope of economical working once more. A comparison of Tables 8 and 9 suggests, however, that their revival occurred somewhat later than the awakening of activity along the outcrops. Only one of the old above-bridge collieries (Montague Main) was important in 1785, whereas six (Benwell, Elswick, Montague Main, East Kenton, West Kenton, and Baker's Main) are mentioned in the list of 1804. These collieries had to face certain problems, notably the presence of large quantities of water lying in the wastes of abandoned workings, which were absent from the new collieries of the Wallsend Basin and less serious for the shallow outcrop collieries. It is possible, therefore, that the greater risk arising from these problems delayed re-winning until a more favourable commercial and technological climate had emerged.

1. NEIMME, Buddle Coll., vol 6, pp 44-45

In 1765 Edward Montague began the preliminaries to a winning of East Denton royalty by securing a lease from William Archdeacon of his one-sixth share of the colliery [1]. The scheme included the winning by outstroke of a large area, some 90 acres, of adjacent Benwell, so that the Beaumont Seam could be worked across the estate boundary. Unfortunately, however, a crucial problem of co-operation between neighbouring colliery owners arose before work had commenced. A memorandum of William Barnes and John Watson reveals its nature:

> The Beaumont Seam at West Denton Engines lies about 16 fathoms deep and the waste, which is very extensive, is standing drown'd ... Lemmington lies to the rise of those engines and East Denton to the dip of them and Benwell lies to the dip of East Denton ... therefore, as East Denton and Benwell are situated to the full dip of West Denton, the water which is in the drown'd waste will penetrate through into those collieries and must, of consequence, be drawn off before the coal can be come at in either East Denton or Benwell. It is therefore most desirable to procure leave of Mr Blackett for to put in proper repair one of his engines at West Denton and to draw off the drown'd waste there ... the water being only to raise 16 fathoms there which will otherwise be to raise 24 in Denton and 30 in Benwell.
>
> Without the engines and liberty of making drains in West Denton your honour's colliery will labour for many years under the inconvenience of wet coals and we shall lie constantly under the apprehensions of being irrecoverably drowned out by Mr Blackett who has it in his power to turn the river Tyne or West Denton Burn into his colliery, all of which water would unavoidably fall upon East Denton engines and overpower them [2].

This is another instance of a problem arising from the irreconcilability

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1. NEIMME, Watson Coll., 9/28, p 1
2. Ibid.

of the pattern of coal ownership with the geological and hydrological nature of the seams themselves. Lemmington and West Denton collieries had worked the Beaumont Seam at shallow depth during the 1730s and 1740s but had been abandoned by this time [1]. The engines at West Denton were apparently still intact or, at least, could be restored. Blackett probably still held a lease and, since he owned the engines, was in a strong position to dictate terms favourable to himself, so much so that at one point Montague threatened a suit in Chancery, a step which greatly alarmed his viewers:

> We have at all times thought it a thing of the greatest consequence to the effectual winning of Denton Colliery for to take a farm of Mr Blackett's engines at West Denton together with the privilege of making cuts and drains in the ground for the taking off top feeders all which we calculate might be worth betwixt 100 and £150 a year to East Denton ... but if a Chancery bill is to be preferred at present it would not only debar East Denton of all those advantages but would be productive of such ill consequence as might render the winning utterly impossible [2].

By 1780 East Denton was working the Beaumont Seam [3]. A view by Richard Brown and Christopher Bedlington in 1785 suggests that there was, as yet, no connection with West Denton Colliery:

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1. NEIMME, shelf 18, Richard Peck's View Book. Mention of a North or Gin Pit and of a South Pit at West Denton in 1733 suggests a small winning. A number of entries in John Watson's journals indicate a vigorous working of Lemmington coal in the later 1740s. NEIMME, Watson Coll., 8/4.
2. NEIMME, Watson Coll., 9/28
3. Ibid.

> We find the workings in that part of Benwell (the 90 acres being worked by outstroke) are, for the present, won by the present fire engine at East Denton and by pumps that lift the water to the said engine [1].

And yet, in an account of East Denton Colliery in 1802, John Buddle observed that

> No engine has been used for many years as the colliery feeders only rise 9 or 10 fathoms up the engine shaft; either finding a way-gate at that level or falling upon West Denton engine [2].

Clearly, at some date between 1785 and 1802, it had become possible for East Denton to be drained with the aid of West Denton engines, and, therefore, to terminate its own pumping operations. In the list of collieries working in 1785 [3] East Denton appears as Montague Main but there is no indication of a colliery at West Denton. Yet Baker's Main is clearly indicated on Gibson's map of Tyne collieries in 1787 [4]. The phrases "for the present", suggesting the imminence of some change, in the report of Brown and Bedlington and "for many years" in Buddle's observations, both quoted above, make it probable that Baker's Main came into production between 1785 and 1787. Both collieries appear in the list of 1804 and both are depicted on Casson's map of collieries and waggonways in 1801 [5].

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1. NEIMME, Watson Coll., 9/28
2. NEIMME, Buddle Coll., vol 14 , p 39
3. See Table 8
4. J. GIBSON, Plan of the Collieries of the Rivers Tyne and Wear, also Blyth, Bedlington and Hartley ... (1787)
5. W. CASSON, Plan showing Collieries and Waggonways on the Rivers Tyne and Wear (1801)

In summary, this evidence, though piecemeal and inconclusive, suggests that the interdependence of East and West Denton collieries combined with a lack of co-operation and agreement between their owners, had a profound effect on the timing and nature of their exploitation. Only when Baker's Main had been won could Montague Main afford to dispense with its engine, an engine which had to be built in the first place only because the respective owners failed to reach agreement on the utilisation of existing engines.

To the north of the Denton royalties and of Benwell, lying astride the Ninety Fathom Dyke, were the two estates of East and West Kenton. Like the other royalties which had shallow coal and easy access to the Tyne, Kenton was the scene of many early workings. William Brown made an exhaustive survey and analysis of the stage which the exploitation of Kenton's coal reserves had reached in 1776. His findings have been reproduced as Appendix C, not only because of their relevance here but also as an excellent example of the kind of survey which a landowner, anticipating the opening of a colliery in his estates, would ask an impartial viewer to make. Kenton was a slightly unusual royalty since it extended between 250 and 350 feet above sea-level, was one of the highest on the Northumberland Coalfield and, therefore, large quantities of the coal it contained could be drained by gravity. Hence Brown's observations that

> if the level had been drove truly thro Benwell it would have laid the Main Coal pits at Slatyford dry without drawing water at all [1].

The driving of drainage levels and drifts was an engineering operation requiring a high degree of accuracy and foresight. Given the rudimentary

1. Newcastle Central Library, Colliery MSS, vol E, p 47

methods and tools available, the geological variables and the difficulty of taking accurate measurements underground, all too often, the finished product was less than perfect. Yet the advantage in working costs that a colliery drained by gravity alone had over a colliery which required pumping apparatus was very considerable indeed.

The re-winning of Kenton, envisaged as early as 1776, did not really begin in earnest until about 1790. By this time Joseph Liddle, Cuthbert Reavely and Christopher Bedlington had agreed with the Bishop of Bristol a lease of East Kenton. Christopher Bedlington, who had established himself as a respected viewer especially among the collieries west of Newcastle, masterminded the winning:

> We propose to take a lease of Mrs Montague ... (for) the liberty of driving a water-level drift from the River Tyne through East Denton and West Kenton estates and to continue the same into East Kenton Colliery for the purpose of winning the same ... also liberty to make roads above ground with convenience to lay rubbish & c that comes out of the said drift or for any other purpose. Also liberty to make use of any of the old or working pits in East Denton and West Kenton Collieries which are already sunk or may afterwards be sunk for the use of driving the said drift or watercourse and drawing the coals, mettle, rubbish, etc ... but for no other purpose ... provided that in so doing we do not hinder the said Mrs Montagues servants or workmen ... [1].

But Kitty's Drift, as the tunnel became known, was to be no mere watercourse. As Bedlington himself stated:

> We also intend to lay a waggon way and sideways in the said

1. Newcastle Central Library, Colliery MSS, vol D, p 29

> drift in order to lead the coals from the said East Kenton Colliery to the River Tyne to a commodious place for a staith.

This ambitious expedient would circumvent both the necessity of drawing water to the surface and the necessity of drawing coal to the surface, each of which were expensive parts of a colliery's operations. The drift would carry both coal and water underground to the Tyne using gravity, the cheapest of all forms of power!

Mrs Montague accepted the lease, gaining £300 certain rent for 1000 tens and six shillings for every additional ten which passed along the drift and through her estate. In 1797 John Buddle observed that East Kenton Colliery was won by

> a capacious drift from Tyne which serves both for a wagonway and watercourse [1]

The winning had multiplier effects. Neighbouring West Kenton Colliery was won by Graham Clark using Kitty's Drift for drainage:

> Now as it was altogether impractical to win the coal under West Kenton estate to the surface and it could not be done but by means of the Tyne Level watercourse from East Kenton Colliery through the Denton estate such colliery would not have been wrought had it not been for the Tyne Level watercourse [2].

Kitty's Drift was 5280 yards long, seven feet high and five feet in width [3]:

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1. NEIMME, Buddle Coll., vol 14, p 39
2. NEIMME, Watson Coll., 9/28
3. NEIMME, Watson Coll., 9/13, f 180

> Horses puts upon an average from the 20 fathom shaft 6 twenty-four peck waggons and will go 4 gait per day [1].

Unfortunately, however, it was not an unqualified success. It arrived at Kenton at too high a level and consequently

> cutts the coal on the rise or west part of the Kenton estate which has only won about 25 acres [2].

Ironically, the hope that a large tract of coal could be laid dry simply by driving an appropriate drainage level had once again not been fulfilled. Such levels were easier to conceive in theory than to construct in practice. The same expedients as William Brown described at Slatyford were necessary at the new winning by 1804:

> The said drift is continued to the full dip of the colliery to the winning now made at East Kenton estate and at a distance of 253 yards along the said drift a staple or pit has been put down 20 fathoms to the seam and the coals are now drawn by a machine into the said Tyne Level Drift. It also draws the water into the said drift which has won about 65 acres more ... [3].

So Kitty's Drift had not provided the panacea for drainage and haulage problems at East Kenton. Nevertheless it served to bring two more collieries into production while the re-winning of Benwell, after a lease had been granted to William Surtees in 1789, and the reopening of

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1. NEIMME, Watson Coll., 9/13, f 180
2. Ibid.
3. Ibid.

Elswick at about the turn of the century [1] completed the revival of coalmining west of Newcastle.

In summary, two processes were of paramount importance in the development of the coal industry in Northumberland between 1760 and 1800. Firstly, the colonisation of the Wallsend Basin brought into production a whole new area of the coalfield where seams had been too deep for economical exploitation thitherto. Here a new genre of collieries emerged with an unprecedented productive capacity, technological sophistication and level of capital investment. They exploited the High Main Seam at depths of over 600 feet and produced prime household coal for the London market. Secondly, the coalfield to the west of Newcastle, which had been an important arena of mining in the seventeenth and early eighteenth centuries but had become derelict by 1740, experienced a marked revival from 1750 onwards. By 1804 there were eight collieries there. In general, they worked seams below the High Main, notably the Beaumont Seam, but were smaller, shallower and produced a poorer grade of coal than the collieries of the Wallsend Basin.

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1. NEIMME, Buddle-Atkinson Papers, 45/4. In 1804 the Committee of the Coal Trade, meeting to arrange the regulation for the following year, refer to Elswick as a "new colliery" and have to estimate its likely vend. NRO, Coalmining Records, List B, Coal Trade Minute Book, 1805-12.

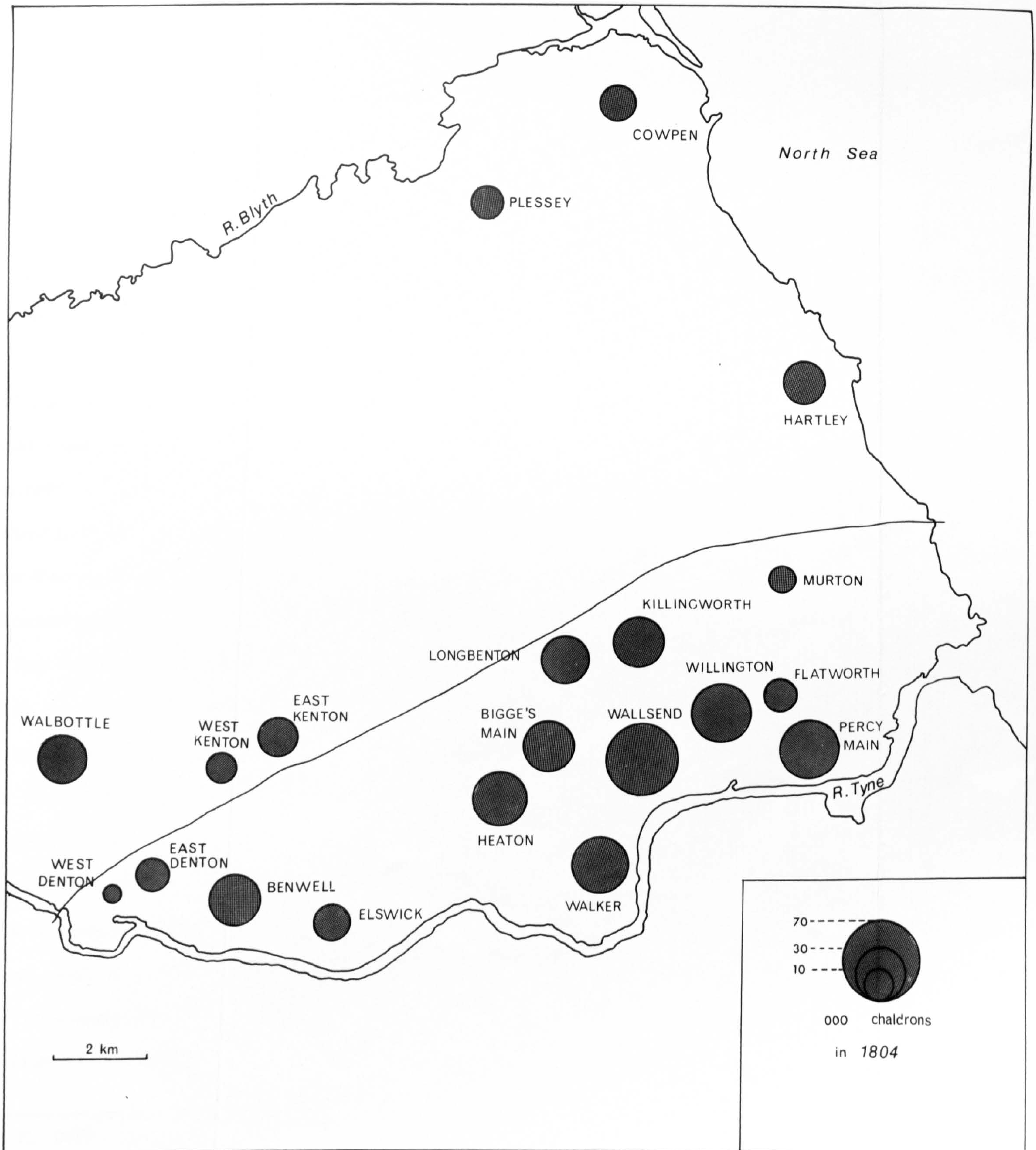

Figure 19 : The distribution of coalmining in 1804

CHAPTER FIVE

NORTH OF THE NINETY FATHOM DYKE

> Immediately after the year 1780 a series of great and organic improvements succeeded each other, not only in the erection of the various steam engines for pumping, but in every other department of colliery engineering; and as the use of coal, under the prosperous state of commerce, was rapidly increasing in all parts of the world, it caused the northern districts of England to flourish in a remarkable manner.

Matthias Dunn wrote this in 1844 [1]. It was an early appreciation that those changes which comprised the first industrial revolution had occurred. "Immediately after the year 1780" coincides remarkably with Rostow's 'take off' date of 1783 [2]. And yet Dunn derived his impression from the expansion of the coal industry in the Tyne-Wear area - with the colonisation of the Wallsend Basin from 1772 - and not from developments in the textile industry, in canal transportation and in overseas trade which provided most of the backing for Toynbee's original thesis of industrial revolution beginning in the mid-eighteenth century [3]. Since the coal industry on Tyneside was geared to supplying markets elsewhere in Britain and overseas it is to be expected that it should be sensitive to outside stimuli. It is, however, a little unexpected that it should grow so spectacularly between 1760 and 1820 [4]. This was not a period of great secondary industrial growth locally. The considerable growth in the iron industry, shipbuilding and chemicals was counterbalanced by the decline of the sea-salt industry, glass and pottery. And the Tyne coal

1. M. DUNN, op. cit., p 50
2. W. W. ROSTOW, <u>The Stages of Economic Growth</u> (1960).
3. P. DEANE, <u>The First Industrial Revolution</u> (1965), pp 2-5
4. See Figure 24

industry was not linked to the other British regions - Lancashire, Yorkshire and the Midlands - where manufacturing was expanding. Moreover, the great increase in the demand for steam coal for transportation which took place after 1825 had yet to occur. A detailed examination of customs records would probably provide ~~the solution~~. But external an answer commerce does not fall within the scope of this work. It may be suggested, however, that expansion was the result both of the expansion of population, industry and wealth in the Thames Valley and near to the east and south coasts of England - the traditional markets for Tyne coal - and of the extension of overseas markets.

Most of the expansion which took place between 1760 and 1800 was accounted for by production from the big Wallsend Basin collieries. By the latter date, however, the area was fully colonised. Moreover, although the collieries at the centre of the basin became the greatest producers of the day, the story was not one of unqualified success. One of the last royalties in the district to be won was Murton, completed in 1799 [1]. Here, right on the eastern rim of the basin, conditions were so bad that the undertakers considered complete abandonment before any return on investment had been gained. A team of investigators advised otherwise in 1799, reporting

> ... that the unfavourable reception which the coal has met with at Market is not altogether owing to a deficiency either in its quality or texture but in some measure to the manner in which it has been wrought and vended. We are therefore far from thinking that such a trial has been made as will justify the measure of laying the colliery in. On the contrary we recommend that the lower seams should be effectually drained ... so as to exhibit the coal in its best state ... While the abovementioned drifts

1. NEIMME, Watson Coll., 12/70

> are going we are of opinion that the coals should be sold to the different Potteries and Foundaries on the river, or to any of the overseas markets but as soon as the working places are in perfect order we advise the Splint Coal and kirvings to be carefully separated from the other part of the seam, and the trial be made of the remainder, but particularly of the top coal at the London and Coast markets [1].

The quality of the High Main in this area was clearly inferior to that further west and at greater depth. This was not unusual. Seams varied areally in thickness, composition and quality. It appears that at Murton the seam had developed a number of easily distinguishable beds and that only some of these yielded saleable coal. The suggestion by the viewers that the good coal could be separated from the bad underground appears optimistic (a great fall in productivity must surely have resulted), hence their advice that the winning should be extended to the "lower seams". The history of the colliery during the ensuing decade corroborated their thinly veiled misgivings.

5.1 The failure of Murton

The management structure at Murton was rather unusual. The owner of the royalty was the Duke of Northumberland. The colliery was leased to a number of shareholders, most of whom were members of the Liddell dynasty [2]. The lessees financed the initial winning but in 1803 they contracted out the working of the colliery to a group of managers - Joseph and Robert Hepple, and Edward Bell - who undertook

> ... the working, drawing, leading and every other expense attending laying of Murton Coals on board of ship at Whitehill Point ...

1. NEIMME, Watson Coll., 12/70
2. Ibid.

> to work 10,000 chaldrons of round merchantable coals out of the Yard Seam and to be paid for the same 14/- per chaldron [1].

The undertakers were soon in trouble. The lessees had allowed them so little margin of profit that even in 1803 they were clearly on the brink of financial loss. The following report offers them little sympathy:

> Allowing that the above quantity (11,200 chaldrons) would be the yearly vend I estimate that they could be delivered at the staith at 15/6d per chald., in which estimate were included the Expense of Fittage with other expenses at the staith, making together 9d per chald. which sums the undertakers were not liable to pay but were defrayed and paid by the owners, consequently that part the Undertakers had to accomplish would according to my estimate cost them 14/9d per chald. And it is presumed that the farms if properly managed would have yielded a profit of £250 per annum which would have been a further diminution of 6d per chald. on the working charges - Hence it appears that if the undertakers had been industrious and had managed the concern in an Economical Plan that they would not have incurred any serious loss by fulfilling their engagement with the owners of the colliery [2].

In 1810 the cost of working and leading from Murton was calculated to be 18/9d per chaldron. Finding that they could only expect to lose money by their exertions the undertakers began to default on the original agreement. And yet in 1804 the colliery made a profit of £1600 and its coal sold at 20/- per chaldron, facts which must have infuriated the Hepples and Bell, saddled as they were, with an unfavourable contract. Two viewers reported that from 5 May 1804 "the necessary exertions have not been made to win and provide coal". In 1805 the 'B' and 'C' pits were

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1. NEIMME, Watson Coll., 12/70
2. Ibid.

laid in and by March "the workmen had nearly all left the colliery". In April "the Colliery Engine discontinued drawing the water out of the colliery - being stopped by undertakers Hepple and Bell" [1]. On the 23rd of that month John Watson visited Murton:

> I awaited upon Mr Joseph Hepple accompanied by Mr Gray when I put the question to him to know if it was their intention to give up the undertaking ... at the end of the Third Year, agreeable to the powers they had by the conditions for taking the same; My reason for wishing to know his determination on that point was that in case it was the undertakers intention that the agreement should cease at the end of the 3rd Year, that the owners might be preparing timber and other necessary materials ... in order to put the colliery into a proper working state again immediately on the expiration of the 3rd Year - To which Mr Joseph Hepple returned me the following answer - "That he could not give me an answer yet, that there was sufficient time before November 1806 to give it and that they would consider about it - He said the owners might give them notice to quit if they thought proper". To this observation I made no reply - I also asked him if we might now begin to put the colliery into a working state again (they having entirely abandoned and laid in the colliery before this time). When he said: "The colliery is there and there would nobody prevent us" but he would not say that he would give us leave, consequently nothing was done [2].

From there the dispute went to the Court of Chancery. On the 26 August the court appointed Ralph Dodds manager of the colliery and he recommenced the working of the pumping engine [3]. It took eight months from that time before the water was lowered sufficiently to begin working the Yard Seam again. The colliery had produced between eight and ten

1. NEIMME, Watson Coll., 12/70
2. Ibid.
3. Ibid.

thousand chaldrons each year from 1800 to 1804. In 1805 it produced only 570 chaldrons [1]. In the following year the colliery was in debt to the Tyne Bank by £3,690.

From this time Murton Colliery recovered under new management and produced coal and ironstone during the next seven or eight years. But the effects of geological adversity, under which the colliery laboured from the outset, could not be deferred for long. In 1814 the following view of the colliery was conclusive in its pessimism:

> The Yard Coal Seam at the Colliery has in its progress to the Northward diminished in its height very considerably so much so that it is impractival (sic) to work it to profit in that Quarter of the colliery; I have therefore been under the necessity of removing the workmen to a piece of coal which adjoins to the Shiremoor Grounds which I calculate will last working about 12 months from this time, after which unless the lessees can have permission to extend their workings into the Shiremoor Grounds the colliery must cease working in that seam altogether, and which you are aware is the only seam that is vendable by itself in this colliery [2].

The winning of Murton Colliery was a failure. The original intention, to work the High Main Seam, was soon thwarted and the exploitation of the Yard Seam was a palliative which merely prolonged the agony. The failure of Murton signified that no more easily won coal could be expected from the Wallsend Basin and that no further expansion was possible there except by intensifying the working of existing collieries. The industry was, therefore, forced to look to the great tract of unwon and largely unexplored coal which lay to the north of the Ninety Fathom Dyke.

1. NEIMME, Watson Coll., 12/70
2. Ibid.

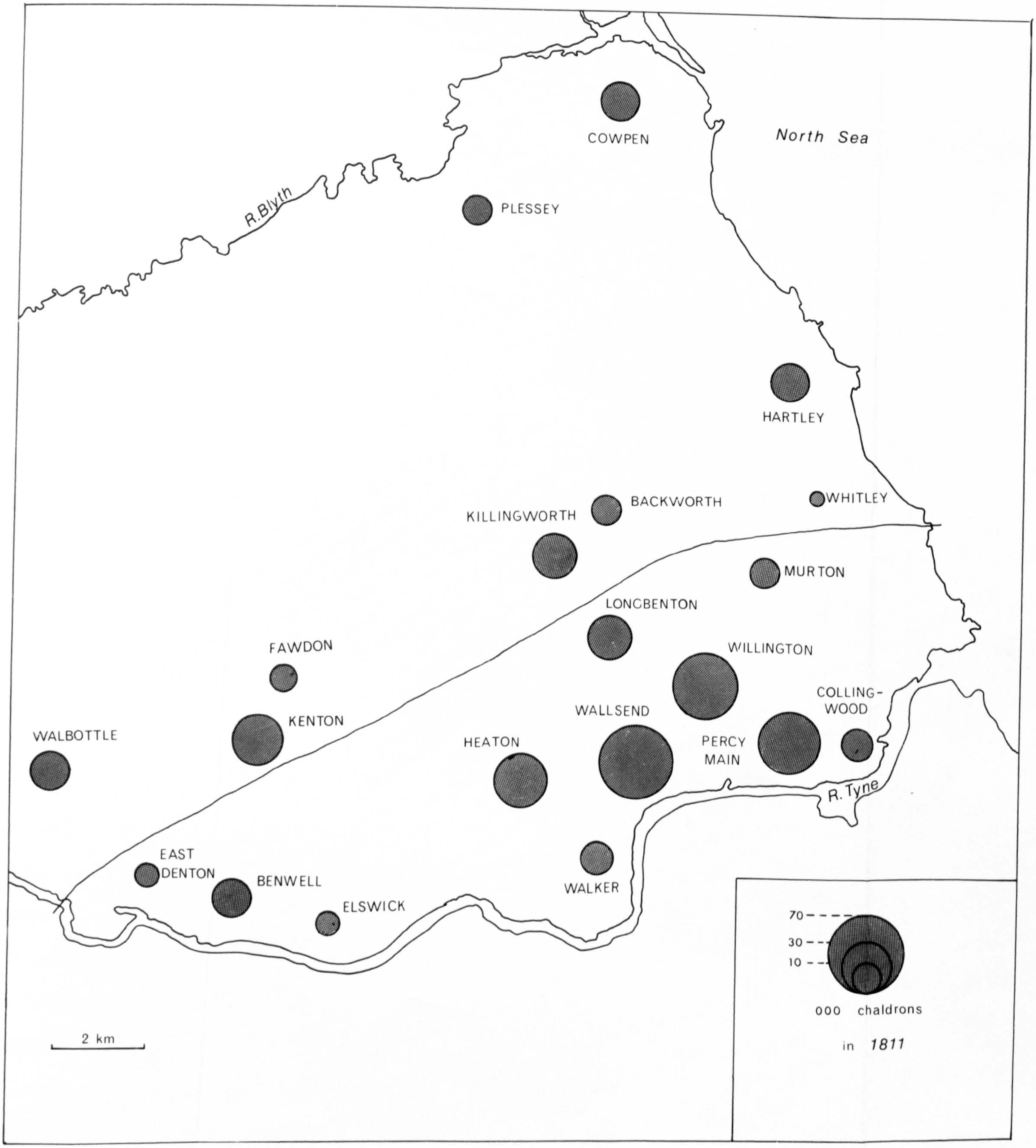

Figure 20 : The distribution of coalmining in 1811

5.2 Breaking new ground: Coxlodge, Fawdon and Gosforth

Miners in the Newburn and Denton district of Northumberland must have become aware of the existence of a large interruption in the horizontal continuity of the strata there at a relatively early date. They became only gradually aware of its extent and direction. It was a downcast fault which had displaced the strata to the north by an amplitude of up to 550 feet and it extended across the Northumberland Coalfield from the Tyne at Lemmington to Cullercoats on the coast. Locally it became known as the Ninety Fathom or Great Downcast Dyke. It had a profound effect on the geographical development of the coalfield since it determined the northward limit of winnings in the High Main Seam until about 1800. In some cases it brought the lives of flourishing collieries to abrupt endings. For instance, from 1689 the Erringtons "... wrought the rise part of the Main Coal in West Denton till the Dyke cast her out" [1].

At the margins of the coalfield, in the zone of outcropping, there were of course winnings northward of the dyke even in early medieval times. But the most easily won outcrops were on its south side and nearer to the Tyne, so they became the scene of the most important early activity. The dyke therefore came to be seen as a natural northern boundary of workings. Since the coalfield was synclinal the movement of mining south of the dyke was essentially convergent from the outcrops towards the centre of the Wallsend Basin. North of the dyke there is some evidence of a similar convergence, especially in the winning of Kenton in 1790 and its later extension to Coxlodge. But because the gradient of the seam north of the dyke was less than the dip towards the Wallsend Basin the influence of depth was not as great there. Consequently the winning of Killingworth by the Grand Allies in 1804 [2] does not fit a simple pattern

1. NEIMME, T.E. Forster Coll., 49/4, p 37
2. NEIMME, Watson Coll., 10/51

of centripetal convergence. Rather it was an extension of winning across the dyke from their sphere of influence at Longbenton to the south (the fact that the Longbenton waggonway could be extended northward was an important factor in favour of the winning at Killingworth). At any rate the success of the colliery proved that the royalties on the north side of the dyke were now within the ambit of economic exploitation.

The next collieries to be won north of the dyke were towards the western outcrop at Fawdon and Coxlodge and both met with great difficulties in their early phases of development. Coxlodge was the first of the two to be won. In 1796 the colliery was leased to the owners of East Kenton who, by 1802, were making preparations to win it by outstroke[1]. But it was too much to expect to win the whole 560 acres of coal in Coxlodge estate by such method. When in 1804 Buddle, Watkins and Watson were asked whether it would be adviseable "...to make an effectual winning in Coxlodge" or merely to extend the working of East Denton into the new royalty by "...driving a drift in the Main Coal Seam from Kenton Engine to the New Pit at Coxlodge"[2] they offered the opinion

> ... that the winning ought to be made at the present sinking pit ... if the feeders met with in sinking down to Tyne Level should become so large as to become too expensive to draw to the surface, in that case we would recommend the Tyne Level drift to be continued from East Kenton and another drift from the winning pit, when sunk to the proper level, to meet the former which would greatly expedite the business - The Establishment of this winning ... would we presume cost about £25,000[3].

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1. NEIMME, Watson Coll., 9/13 ; Buddle Coll., vol 14, p 24
2. NEIMME, Watson Coll., 9/13
3. NEIMME, Watson Coll., 9/13

The spatial and technical aspects of the rather complex winning of Coxlodge are considered later [1]. At first the prospects of the venture appeared good. Thomas Fenwick observed in 1807 that

> ... As Kenton Colliery is nearly exhausted little need be said about it, but with repect (sic) to Coxlodge from the nature of the Coal, and the roundness with which it will go to market, I have no hesitation in saying there are the most flattering prospects [2].

In the meantime, however, East Kenton, its productive life almost at an end, was losing money steadily. In 1809 John Watson pointed out

> ... that a score of 24 peck corves (under the present state of the colliery) will cost laying on board ship ... 34/3 per chaldron, the selling price of which is at 31/- per chald., consequently there is a loss of 3/3d per chaldron [3].

By the following year, however, the new colliery had begun to yield coal and the total output from Kenton and Coxlodge Collieries doubled over the next three years [4]. In 1811 it was estimated that an annual profit of £10,000 might be expected for 22 years on an annual vend of 30,000 chaldrons [5]. But this calculation was prematurely optimistic. On August 24th, 1812 Thomas Fenwick and Thomas King replied to the owners:

> ... having maturely considered ... as to the ultimate prospects

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1. See pp 320-6
2. NRO, Ridley Coll., ZRI/35/22, p 84
3. NEIMME, Watson Coll., 9/13
4. NEIMME, Buddle Coll., vol 3, p28; Watson Coll., 9/12
5. NRO, Ridley Coll., ZRI/35/22, pp 85-7

> of the concern, after having extracted a variety of payments and c. from the colliery pay bills, books and c., we find a chaldron of coals delivered on board of ships or keels at Carville Staith, costs the owners of this concern £1 - 7 - 9½d and ... an average of the coals sold in 1811 amounts to 30s 1½d ... leaving a profit of 2s 4d a chaldron, which on an annual vend of 30,000 chaldrons ... makes the annual profit of £3,500. This profit, we consider trifling for the capital employed in these collieries ... [1]

The main problem was high working cost. Coxlodge was a deep colliery with a more arduous haul to staith than any other in Northumberland at that time. Kitty's Drift, which had served to deliver East Kenton coal to Scotswood, was inadequate for the greater flow from the new colliery and was abandoned for leading in 1808. In its place a five-mile haul via an extension of the Bigge's Main waggonway was used by which Coxlodge coal was delivered to staith at Wallsend, nine miles lower down the river. Thirty wagons were employed with six additional 'helping up' horses. The carriagemen were paid 2s 10d per 'gate' (journey) and could make 15 journeys a week during summer and 13 in winter on average [2]. As a result the cost of leading was very great. Not surprisingly in 1812 it was suggested, "considering the enormous expenses attending the horses" [3], that leading the coal should be contracted to an outside body. It must have seemed like a godsend to the owners when John Blenkinsop offered his 'Travelling Engines' as a solution to their transport problems. In April 1813 an arrangement was agreed by which the Coxlodge owners were allowed

> ... the use of his mode of leading by virtue of a Steam Engine

1. NRO, Ridley Coll., ZRI/35/22, p 92
2. NEIMME, Johnson Coll., 4/5, p 113
3. NEIMME, Watson Coll., 9/11

> - the owners paying him for such liberty for the first year commencing January 1814 fifty pounds ... [1]

But any hopes of a panacea for Coxlodge which Blenkinsop might have provoked were soon dispelled when Fenton, Murray and Wood, the Leeds engine builders, wrote

> ... candidly to observe it is not the kind of engine I would recommend for your purposes, as the Boiler is calculated only for Mr Blenkinsopp's short distances and in course will require more times refilling with water in yours. Another objection is the rack wheel being fixed on one side of the road instead of the middle, this causes the wheels of the engine to wear away very fast and proportionably the rails ... I make these observations for you to consider of in beginning this business as you know it cannot be altered afterwards without being at great expence (sic) & in short beginning over again ... [2]

The colliery owners were in a dilemma indeed. Suffering from financial losses due to surface haulage, they were presented with an innovation which would soon revolutionise transport. But the new mode was still clearly imperfect so what faith could they place in it? A few years later William Hedley would prove that locomotives could run on smooth rails and that Blenkinsop's 'rack wheel' method of traction was completely unnecessary.

In the meantime the problems were too much for the proprietors of Scarborough Bank who sold their seventeen twentieths of the colliery for £60,000 [3]. The purchaser was Samuel Williams who was almost immediately

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1. NEIMME, Watson Coll., 9/13
2. Ibid.
3. NEIMME, Watson Coll., 9/12

at odds with John Watson, one of the smaller shareholders. Williams' complaint was that Watson had misrepresented to him the true value of the colliery. More probably Watson, anxious to secure a buyer, minimized the difficulties the colliery was facing. Furthermore, he apparently told Williams that the profits accruing from the colliery could be expected to cover the later instalments to Scarborough Bank. But this did not come about owing to a slump in the coal trade caused by " ... the most unprecedented continuation of contrary winds" [1].

Samuel Williams then appears to have embarked on an extremely unco-operative course of action which led him ultimately to the Court of Chancery. In the first place he dispatched his brother, Charles Williams, to the north to take charge of the concern. The latter began to make a number of extreme economies. He dismissed the existing viewers and managers

> ... without any sufficient cause or reason ... and appointed others in their stead, and ... greatly reduced the number of hewers that were employed upon the colliery and ... made various other alterations in the manner of carrying on the same ...[2]

Perhaps his most unwise decision of all was to appoint Thomas Easton, the viewer of neighbouring Fawdon, a colliery in direct competition with Coxlodge, as visiting viewer and adviser to Coxlodge Colliery; "... such an appointment was highly impolitic and unadviseable" [3]. When four viewers - Thomas Fenwick, George Hill, James Jobling and William Stobart - at John Watson's request, reported on the state of the colliery in

1. NEIMME, Watson Coll., 9/10
2. NEIMME, Watson Coll., 9/12
3. NEIMME, Watson Coll., 9/10

May, 1815, they condemned some of the economies made by the owners:

> ... with respect to the coal workmen engaged this year, it is in our opinion inadequate to raise this quantity (i.e. the stipulated quantity of 33,000 chaldrons) ...
>
> ... the number of wastemen at present employed is inadequate to keep the waste in a safe state ...
>
> There are at present three shifts of pitmen employed and only two overmen to manage these three shifts, another overman we think indispensably necessary ...
>
> ... as well as a Resident Underviewer, to inspect daily both the workings and the waste ... These additions in the Underground Establishment we think ought to take place immediately ... [1]

Some of the economies were of dubious legality;

> Mr Williams and his agents did grant permission to the owners of Fawdon Colliery liberty to take the Kenton and Coxlodge coals at the staith and put them on Board of the Ships that were loading with the Fawdon Coals, and sending them under that certificate to the Markets ... It is unquestionably an illegal act ... it must have brought these coals into as degraded a state as the Fawdon Coals are at Market [2]

John Watson appears to have been almost driven to distraction by these measures but, in the event of the complete breakdown of relations between the partners, was powerless to act. He comments

> ... it is much to be feared ... the consequences (of such economies) may not only be serious to the concern, but

1. NRO, Ridley Coll., ZRI/35/22, pp 122-3
2. NEIMME, Watson Coll., 9/10

> lamentable to the people employed, as has too frequently been the case by such neglect, and by the improper management in concerns of this hazardous nature [1].

The most costly area of working expenditure at Coxlodge was surface haulage. The economies enacted by Charles Williams and Thomas Easton were draconian to say the least.

> In consequence of the horses being so improperly fed they became so reduced that they were not able to lead more than 978 chaldrons a fortnight while they should if they had been in a proper state have led about 1700.

The horsekeeper at Coxlodge could remember one of Easton's agents

> ... coming to the stables about August 1814 and giving directions that the Hay given to the horses on the waggonway while at work was to be discontinued. And also the Quantum of corn they had been weekly allowed should be reduced ... [2]

But the most retrogressive steps taken affected the locomotive haulage for which the Coxlodge waggonway had just been adapted;

> Thos. Easton (an agent of Mr Williams appointing) ordered the travelling engines, which are also employed in leading coals from the colliery, to be removed from the situation where they were considered to be most eligibly placed for doing most work, to a rising hill, where it is found by experience they cannot do half the work that they were able to do on the other part of the Road. This measure, so visible to everyone of its impropriety, could only be adopted ... to prevent the Engines

1. NEIMME, Watson Coll., 9/10
2. Ibid.

> incommoding the leading of coals from Fawdon Colliery, wherein this agent is materially interested ... [1]

One of the enginewrights at Coxlodge testified that Easton had subsequently

> ... placed improper and ignorant men to work the said engines so that by their mismanagement the Engines have been rendered unserviceable and laid entirely aside ...these locomotive engines were so mismanaged with the connivance of Easton that they might not interfere with the Fawdon coals leading ... [2]

Easton's influence seems to have permeated every facet of the colliery's life. Watson observed that since his appointment "... many of the houses belonging to Kenton and Coxlodge Collieries have been occupied by workmen belonging to Fawdon" [3]. Easton's intentions are all too clear but the policy of the Williams' appears peculiarly self-destructive. John Watson gives some clues as to their motives. In 1815 he wrote gloomily to his colleague Joseph Bainbridge,

> You will no doubt have been informed by Messrs. Atkinson and Wilde that Mr Williams had filed a bill in Chancery against you and I in order to compel the sale of Kenton and Coxlodge Collieries ... I shall of course put in my answers to it and also refer to the court to interfere in appointing a proper person to take the general management of the concerns ... as I am fully convinced that unless some step of this kind is immediately done, the concerns must go to destruction which must be to your injury and my ruin ... Before I left there things seemed to be as bad as they could be; but since which

1. NEIMME, Watson Coll., 9/10
2. NEIMME, Watson Coll., 9/12
3. NEIMME, Watson Coll., 9/10

> I have had the most dismal accounts. I find that fellow Thompson is still there and continually drunk or thereabouts. And it appears there is no one left to take an account of the time the labourers are at work or look after them - It seems everything is in a dreadful state indeed [1].

There was thus a complete breakdown in the management of the colliery. Production slumped from over 35,000 chaldrons in 1812 to under 23,000 in 1816.

But what is the relevance here of this dismal chronology of dispute and decline. Simply that it shows that the changing geography of the coalfield cannot be explained purely in terms of the interaction of technology, natural conditions and market stimuli. Human motive and behaviour, in all its erratic variety, also had a profound impact, not only the rational and predictable profit motive but also the irrational pursuit of power and reprisal. At Coxlodge the dispute affected the progress of technology as well as the geography of extraction. It also affected the careers of the protagonists. John Watson, who had contributed hugely to the development of the coalfield since 1750, was declared bankrupt in 1825 [2], and died a few years later. The colliery itself survived. Samuel Williams sold his share to C. J. Brandling for £38,500 in 1817 [3]. Under new ownership it recovered and prospered. In 1825 it produced over 36,000 chaldrons [4].

Neighbouring Fawdon, where Thomas Easton was viewer, had problems of its own. The steps which were taken to win the colliery from 1809 represented the same eastward trend of colonisation from the western outcrop as the

1. NEIMME, Watson Coll., 9/11
2. NEIMME, Watson Coll., 9/10
3. NRO, Ridley Coll., ZRI/35/22, pp 126-32
4. NRO, Coalmining Records, List B, Coal Trade Minute Book, vol I

Coxlodge winning. Fawdon was the smallest of six adjacent royalties north of the Ninety Fathom Dyke which were owned by Sir Arthur Hesilrigge. The total extent of coal in these estates was estimated at 4,532 acres. It was calculated that, if wrought together as one colliery, they could supply an annual vend of 33,000 chaldrons for a period of 111 years [1]. Since it was the nearest of the six to existing collieries and to the river, Fawdon was the most eligible for initial colonisation. It was first advertised in 1779 but there were no takers [2]. In 1809, however, Cramlington, Smith and Row took a 21-year lease to work 2,600 tens a year and the pay for them a certain rent of £2,600. In 1810, adopting a purely parasitic role, they sub-let the colliery to John de Ponthieu at a certain annual rent of £3,000 for 2,400 tens [3]. The new sub-tenant immediately began to sink an engine pit and reached the High Main at a depth of 47 fathoms (86 metres) [4].

But the winning was a dismal and costly failure. John Buddle called it " ...one of the most embarassing cases that ever came before me" [5]. The problem was as old as coalmining; the poor consolidation of roof cover.

Buddle and Fenwick made certain recommendations in 1812 by which the colliery might struggle on;

> The Cover of the seam is so bad to the North West of the Engine Pit and in the vicinity of the present sinking pit, as to put it out of power to point out any plan by which the expence (sic) of working can be lessened.

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1. NRO, Ridley Coll., ZRI/35/22, pp 170-1
2. NEIMME, Watson Coll., 9/7
3. Ibid.
4. Northumberland County History, vol XIII, pp 54-5
5. NEIMME, Buddle Coll., vol 3, p12; NRO, Ridley Coll., ZRI/35/22

> We can therefore merely recommend that the workings of the mine should be pursued vigorously in that direction where the least annoyance and expence is occasioned by the badness of the roof ...
>
> As the workings are opened out in this quarter the workmen may be successively withdrawn from the North West division of the colliery ... [1]

Despite these suggestions, however, it is clear that the viewers nurtured little hope for the future;

> ... it is also evident that the present winning can only obtain a very limited tract of the Royalty and is not therefore capable of affording the requisite supply of coals but for a very limited period ... I see no plan whatever of giving the concern a fair chance of yielding profit except by making an entire new winning near to the full dip of the colliery [2]

An ailing colliery could not expect to survive long where the output of other collieries was kept below capacity by an artificial regulation. Not surprisingly John de Ponthieu sold the colliery in 1813 and it was re-won and worked subsequently by Newmarch and Sons [3].

It is clear then that some of the first collieries to win coal north of the Ninety Fathom Dyke were unsuccessful. The difficulties which accompanied the winning of Backworth, located similarly to Fawdon and Coxlodge, are examined later [4]. These new collieries faced abnormal difficulties. They were colonising an area where knowledge of geological conditions

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1. NEIMME, Buddle Coll., vol 3, p12; NRO, Ridley Coll., ZRI/35/22
2. NEIMME, Buddle Coll., vol 3, pp 12-3
3. NEIMME, Watson Coll., 9/7
4. See pp 221-4

was less developed than in the established area of extraction south of the dyke. Their longer hauls to staith necessitated costly wayleave concessions. Moreover, disputes which arose at Fawdon and Backworth [1] suggest that landowners were less inclined to accept passively environmental disturbance and despoliation outside the established areas of industrial development. The area north of the Ninety Fathom Dyke was prime agricultural land, amongst the best in the county. Its disruption and destruction for the transient rewards of coalmining were not to be taken lightly.

5.3 Further afield: Backworth and Seghill

By 1820 there were four major collieries north of the dyke at Fawdon, Coxlodge, Killingworth and Backworth [2]. The winning of Gosforth, proposed and planned as early as 1816 was not commenced until 1824 [3]. By that time two further winnings of more limited scale, at Earsdon and Whitley, had added to the line of new collieries which stretched from Walbottle to the coast on the north side of the dyke [4].

Except in the Killingworth area the High Main Seam to the north of the dyke lay at shallower depth than to the south [5]. Northward of the dyke, therefore, winnings became simpler and cheaper, at least by the standards of the Wallsend Basin. The pits in the Cramlington and Seghill area were usually less than 25 fathoms (86 metres) deep. As a result the cost of winning was no longer the main determinant of viability. Surface haulage had become the major variable in the 'cost of laying a chaldron of coal on staith'. In consequence a major factor in the pattern of development

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1. See pp 223
2. See Figure 21
3. NEIMME, Watson Coll., 10/38
4. See Figure 22
5. See Figure 8

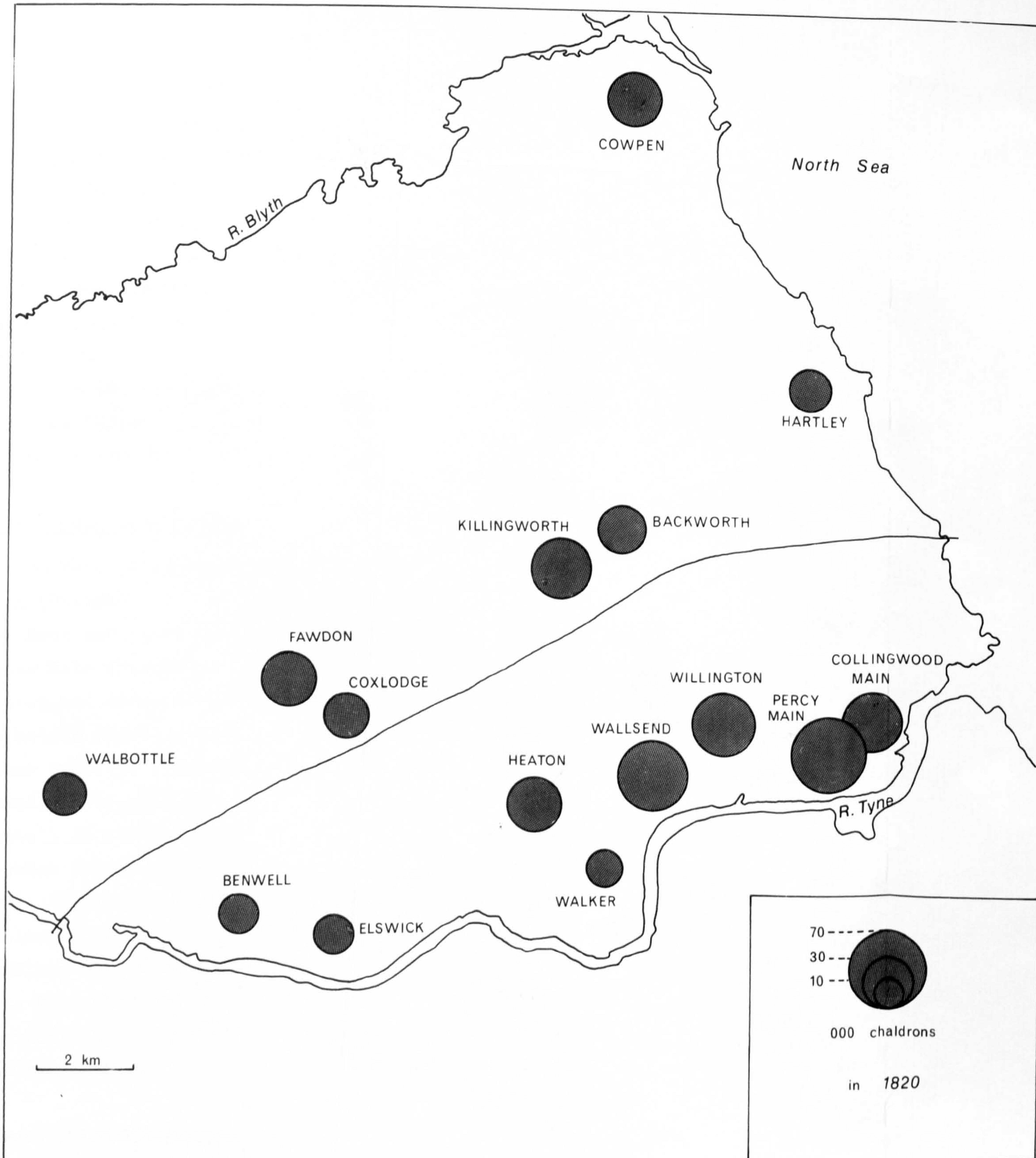

Figure 21 : The distribution of coalmining in 1820

TABLE 11 : Vend of coal from Tyne and Blyth collieries in 1820

First Class collieries	Vend in chaldrons
Percy Main (Northumberland	66,389
Wallsend (Northumberland)	54,762
Hebburn (Durham)	53,448
Willington (Northumberland)	48,400
Killingworth (Northumberland)	39,066
Fawdon (Northumberland)	36,489
Heaton (Northumberland)	32,341
Jarrow (Durham)	28,000
Backworth (Northumberland)	26,312
Coxlodge (Northumberland)	23,000
Walker (Northumberland)	16,000
	424,207
Second Class collieries	
Burdon Main (Northumberland)	43,026
Team (Durham)	35,616
Low Moor and South Moor (Durham)	29,776
Pelaw Main (Durham)	27,443
Pontop and Garesfield (Durham)	26,009
Walbottle (Northumberland)	21,640
Manor Wallsend (Durham)	20,000
Townley Main (Durham)	18,196
Benwell (Northumberland)	17,726
Elswick (Northumberland)	16,569
Wylam (Northumberland)	15,333
Felling (Durham)	15,000
Tanfield Moor (Durham)	13,861
Tyne Main (Durham)	13,621
Sheriff Hill (Durham)	12,457
Usworth (Durham)	9,328
	325,591
Cowpen (Northumberland)	32,314
Hartley (Northumberland)	21,000
	53,314

Source: NRO, Coalmining Records, List 60, vol VII.

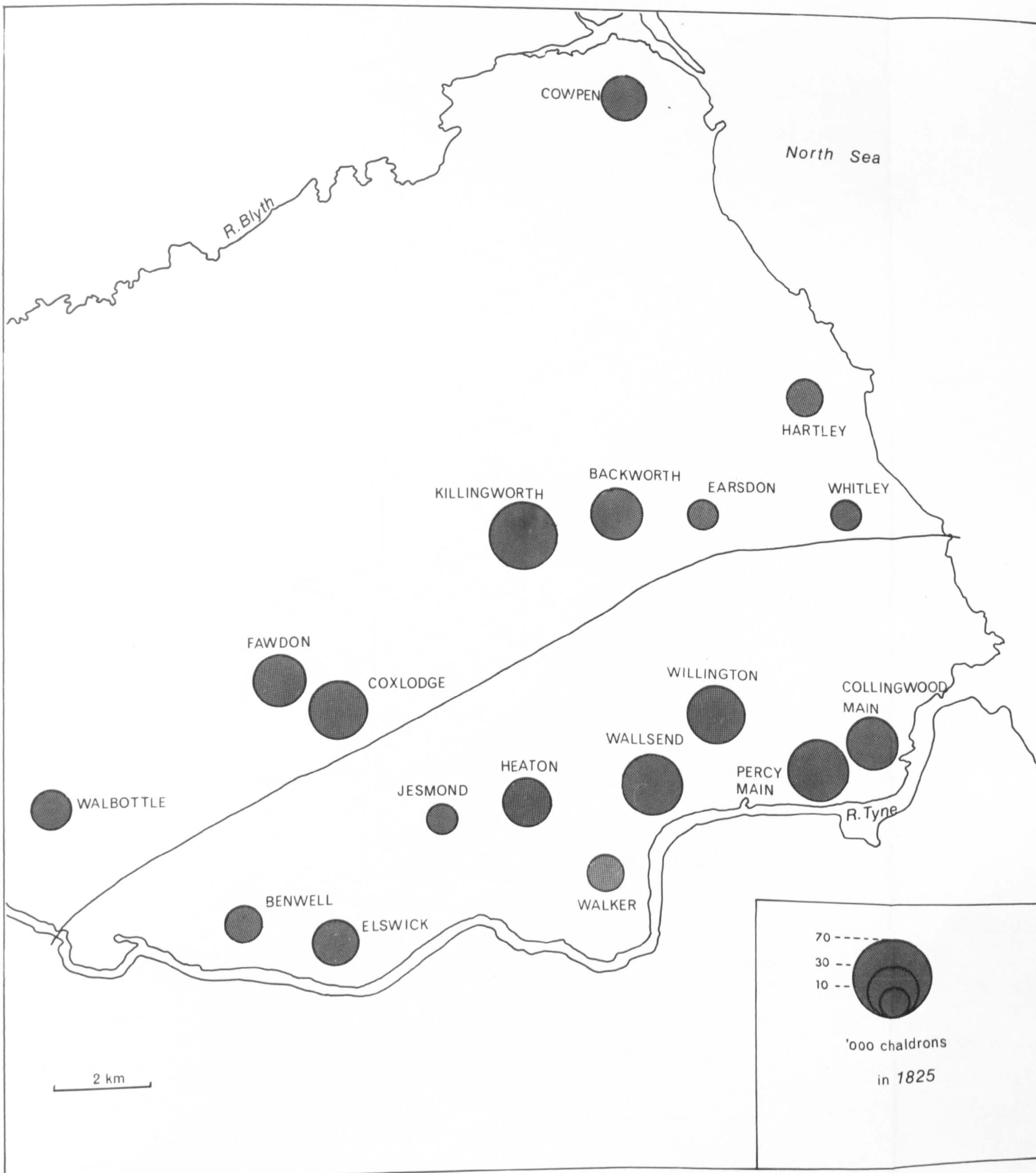

Figure 22 : The distribution of coalmining in 1825

north of the dyke was the pre-existence of railway links to the Tyne (the possibility of transhipment from the coast was eliminated by the gradual failure of Seaton Sluice as a coal-shipping port [1].

That competition for the use of the Coxlodge waggonway led to strife between Fawdon and Coxlodge collieries has become apparent already. When the winning of Gosforth Colliery was being planned in December, 1816, John Watson worked on

> ... the presumption that the coals are to be led down the Kenton and Coxlodge waggonway as far as circumstances will permit, so that there is not above 1000 yards of Main Way calculated for ... [2]

Nevertheless the cost of provision for surface haulage exceeded £4,500 not including the £3,000 for the building of a new staith.

More important than the Coxlodge waggonway in encouraging the opening of new collieries were those lines which penetrated deeply into the area north of the Dyke from staiths at Howdon and Whitehill Point. The first to be built was the Backworth waggonway which was begun in 1818. It was followed some five years later by the Cramlington Colliery Railway and later still by the Brunton and Shields Railway [3]. The construction of these new iron railways, employing standing steam engines, locomotives and inclined planes for haulage, presaged the end of the old horse waggonway system. They focused on the riverside between Howdon and Whitehill which, especially after the building of the Northumberland Dock in 1857, became the great transhipment point for Northumberland coal. As

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1. See my article appended.
2. NRO, Ridley Coll., ZRI/35/22, pp 106-19
3. See Figure 29

a result, many of the staiths and spouts higher up the river fell into disuse.

It was probably the building of the Backworth waggonway which suggested to a partnership of John Carr, his son, John Robson and William Coates that Seghill might now be within the ambit of profitable exploitation. Significantly, when enquiries were made as to the "... chance of success in a colliery of about 1300 acres situated near Killingworth, Burradon and Backworth 6 miles from the Tyne", the provisos were that it

> ... depends on the state in which the coal is found to lie, the quantity thereof, strata to be sunk through and line of waggonway to be obtained to the River Tyne [1].

New railway technology - iron rails and wheels, steam haulage and such - had greatly economised day to day haulage costs but at the same time raised the level of initial capital investment. Consequently the owners of Seghill hoped to use part of the Backworth waggonway for transporting their coal to the Tyne. They wrote to the Backworth owners in 1824;

> His Grace the Duke of Northumberland has been pleased to grant us a wayleave over his lands lying between the Seghill property and the River Tyne ... We should therefore be glad to treat with you for a similar leave over your own property which intervenes; and at the same time we should feel obliged if you will point out the facilities you can afford in allowing us the use of any and what part of the machinery you have now employed in conveying the waggons along the railroad, and what part of the way we could pass along in leading our coals without incommoding your proceedings ... [2]

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1. NEIMME, Watson Coll., 13/95
2. Ibid.

The Backworth owners had little hesitation in granting wayleave but to allow Seghill to use their waggonway itself was an entirely different matter. The line was already overburdened. Nevertheless they replied diplomatically

> ... with respect to our present waggonway and machinery thereon we beg to assure you that we feel every disposition to render them useful to your colliery but we have some doubts whether this can be done without obstructing the leading of coals from His Graces Three Collieries & we wish to leave this point open to future duscussion (sic) ... [1]

But it transpired that no compromise was reached. Fortunately for Seghill the Cramlington Colliery Railway, completed in 1825, offered an alternative and the owners of Cramlington, anxious no doubt to recoup some of their recent expenditure, were more amenable. An agreement was reached;

> ... the point from which the Cramlington Lessees will commence to lead the coals from Seghill Colliery to be at the Branch Ends at Seghill Winning and the point at which they will cease leading the same to be at the head of an Inclined Plane about Two hundred yards from the Staith.
>
> ... the Seghill Lessees to pay the Cramlington Lessees the sum of three shillings and six pence a chaldron for each and every chaldron of coals they may lead ... [2]

Seghill thus resolved what appeared to be its most pressing difficulty. Another of perhaps greater overall significance had already arisen. Although the owners of Seghill were unaware of it at the time they began

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1. NEIMME, Watson Coll., 13/95
2. Ibid.

winning; their colliery lay at the northern limit to which the High Main Seam extended in its normal state. Further north it deteriorated rapidly in quality and diminished in thickness. In fact the High Main Seam, the quest for which had dominated coalmining in Northumberland for two centuries and been inextricably interwoven with the progress of coalmining generally, was approaching exhaustion. Although High Main Coal would be shipped to London and command the highest prices there for another three decades the paucity of reserves was becoming apparent even in 1825.

Of course this was not immediately apparent to the owners of Seghill. In fact borings in the north of the estate had discovered a new workable seam, the Grey Seam, and this seemed to more than outweigh the slight deterioration in the High Main detectable from boring cores;

> ... our principle object when we commenced the borings was to ascertain the High Main Coal Seam now working at the adjoining collieries of Backworth and Burradon but during our proceedings to do so a second seam, unknown in this neighbourhood, was discovered lying ... in great perfection in the northern part of the estate ... [1]

It was thus with optimism that the owners solicited the advice of John Buddle, Matthias Dunn, George Johnson and Nicholas Wood, probably the best coalmining brains then available, as to

> ... whether it would be more advisable to make the winning and place it in a situation to attempt the winning and working of both seams or a winning in the first instance of the High Main Coal alone or would advise a winning of the New Seam ... [2]

1. NEIMME, Watson Coll., 13/95
2. Ibid.

The viewers replied that either

> ... the High Main Coal in the southern part of the property. Or the lower seam in the northern part of the same; is of sufficient importance to justify a winning of either; but as we observe the High Main Seam deteriorates on its approaches northwards, while the lower seam deteriorates approaching southwards ... we do not think a general winning can be made in both seams ... in any centrical (sic) position ... [1]

Nevertheless, all seemed well even if two separate operations would be necessary. But despite the relative shallowness of the seams and the relatively sophisticated technology available by then the winning was far from trouble-free. In the first place the initial sinking failed to uncover the seams in their expected state. Whether this was due to freak geological conditions, or to negligence on the part of viewers and sinkers, or to other factors, is difficult to ascertain. In the event Buddle, Dunn, Johnson and Wood took the whole thing very seriously, observing

> That the seams on the south or dip side of the 25 fathom dyke are not worth pursuing and therefore that the present winning ought to be relinquished.
> That if the colliery is to be ultimately pursued it must be by a new winning on the rise side of the dyke ...
> That as the decision of this question hinges mainly on the reception which the Cramlington Coal may meet with at Market, it is prudent to wait the event of the Cramlington Coals going to market before the question is decided ...
> That the cast iron tubbing be taken out of the present Engine Pit without delay, and that all expenses immediately cease ... [2]

1. NEIMME, Watson Coll., 13/95
2. Ibid.

These were desperate measures indeed. They did not meet with the approbation of John Watson. After undertaking his own investigations he completely refuted the conclusions of the four viewers. His report is worth quoting at length. It perhaps shows that in the business of coalmining there is no substitute for experience and, in 1826, no viewer was more experienced than John Watson.

> Conformable to the statement I made to you a few weeks back that I could open to view at a very inconsiderable expence (sic) the different seams of coal in the pits which have already been sunk at Seghill Colliery, Notwithstanding the opinion which had been given by four eminent professional gentlemen which sett forth "That the seams on the south or dip side of the 25 fathom dyke were not worth pursuing and recommend the present working to be relinquished ..." ... I could not bring my mind to the same conclusion as to coincide with them in any respect whatever either as to where the seams in question lay or their quality ... but on the contrary I was more and more convinced I was right in the opinion I had formed as to the seams having been passed in the sinking of the present pits ...
>
> Those experiments which I proposed to make have been undertaken and I am happy to say both the High Main and Grey Seams have been found in great perfection as well as the Hartley Yard Seam which has been also sunk through by the pit having been injudiciously sunk beyond the original intention.
>
> I should not have passed over making a few remarks as to opinions given on this important subject from time to time by my professional Bretheren but in the belief it would only tend to unpleasant feelings I shall therefore refrain from doing so, nor shall I make any observations on the Great Capital unnecessarily expended in prosecuting the winning [1].

Watson was clearly triumphant that his opinions and instincts had

1. NEIMME, Watson Coll., 13/95

prevailed. His jubilation did not last. Despite the advice proferred above that "... a general winning ... of both seams ... in any centrical position ..." was not feasible, this appears to have been the kind of operation which was attempted. The two pits were sunk in the middle of the estate on the south side of a 25 fathom dyke which bisected it in a north-west to south-east direction. Predictably, because the winning was shallow it soon encountered drainage difficulties which forced the owners once more to canvass expert opinion;

> The measures in progress for the winning of this colliery having been lately interrupted by unexpected and alarming feeders of water you are requested to examine ... the nature of the feeders, the Engine Power, as well as the projected enlargement of the pumps and c. ...
>
> The present winning you will observe is ... on the south or dip side of a 25 fath. Dyke running in a north westerly direction - On the rise side of this dyke and at the Mares Close Hole the Grey Seam is proved to be 44 faths. deep. Whereas in the present winning pit it lies at a depth of 67 faths.
>
> At 45 fathoms in the said winning is the 2ft. 10 ins. seam which is supposed by comparative borings and levellings to be about 10 feet below the Grey Seam. This coal was therefore thought to afford an opportunity for drifting through the Dyke, as a rolley road for the Grey Seam, but on trial it was found to dip in that direction, and on raising a feeder of water it was found to be no longer practicable.
>
> An underlevel drift (16 feet below the coal) was then resorted to and at the time the sinking towards the Main Coal Seam continued. Whilst the drift has advanced 50 yards the pit has reached within 5 feet of the Main Coal, but in both places the feeders of water have so progressively increased that doubts may justly be entertained as to the present means being adequate

to carry the desired objects into effect [1]

The drainage difficulties were gradually circumvented, initially by abandoning the simultaneous winning of the Grey Seam and concentrating on the High Main.

5.4 Conclusion to part one

Despite two centuries of great technological progress - the introduction and refinement of railway haulage, steam pumping and drawing, elaborate systems of ventilation - the opening and initial working of Murton, Coxlodge, Fawdon, Backworth and Seghill suggest that coalmining remained problematical. There is no evidence that extraction became safer for workers or more reliable generally. On the contrary the record of disaster in the first half of the nineteenth century is, if anything, more horrific than before. Between 1803 and 1843 1,446 miners died in accidents in Northumberland and Durham [2]. Because the scale of operations was greater the scale of disaster, when it occurred, was proportionately greater. After 1820 the average depth of working in Northumberland actually decreased as the emphasis shifted from the Wallsend Basin to shallower coal north of the Ninety Fathom Dyke. Although this eased underground haulage and ventilation problems it increased drainage difficulties since the wetter strata tended to be nearer the surface. In fact there seemed to be no formula by which explosion, innundation and entombment could be avoided simultaneously and, at the same time, the working of coal be pursued profitably. Consequently a high mortality underground had to be accepted as an unfortunate but apparently unavoidable corollary of man's quest for coal.

1. NEIMME, Watson Coll., 13/95
2. NEIMME, Bell Coll., 15/11, p 472

In 1828 John Buddle made a survey of the coal industry on Tyneside. A synopsis of his findings relating to Northumberland is presented here [1]. It represents a fairly complete account of the state of the industry at that date, especially when considered in conjunction with Figures 22 and 29. By this time there was no part of the coalfield between Tyne and Blyth which was not within reach of navigable water. The Cramlington Colliery Railway had breached the watershed between Tyne and Blyth coal catchment since Cramlington was working strata adjacent to old Plessey Colliery which had always shipped from the Blyth [2]. Only two collieries, Cowpen and Hartley, remained independent of the Tyne and were not included in Buddle's survey. Even Hartley was later linked to the River Tyne when the harbour at Seaton Sluice eventually became unnavigable. Equally there was now no coal in this area beyond the technological limits of extraction. In 1838 Monkwearmouth Colliery reached a depth of 270 fathoms (over 490 metres) [3]. This was far deeper than any pit in Northumberland at that time. The role of accessibility as a geographical factor influencing the spatial development of coalmining between Tyne and Blyth was thus greatly diminished.

Moreover, the areas near the Tyne were already declining as new mining districts, now within haulage range of the rivers, were developed [4]. Whereas output from the district between Tyne and Blyth had topped 500,000 chaldrons (1,351,500 tonnes) in 1820, it was less than 350,000 in 1849 [5].

---

1. See Table 12
2. See Figures 28 and 29
3. NEIMME, Bell Coll., 15/11, pp 203-287; a copy of 'The Economy of a Coalfield', a lecture delivered by F W Johnston of the University of Durham to the Geological and Polytechnic Society of the West Riding in August, 1838.
4. A. E. SMAILES, North England (1960), pp 164-5
5. NRO, Coalmining Records, List B, Coal Trade Minute Books, vol 5; NEIMME, Watson Coll., 13/91

By then production was more evenly distributed throughout the whole coalfield and, indeed, the whole country. The advantage which south-east Northumberland had enjoyed due to the excellence of the High Main Seam and proximity to navigable water had been substantially reduced.

Finally, Figure 23 shows the distribution of productive collieries in 1848. By this time virtually every royalty had been colonised, although Newsham was won as late as 1877 [1]. Moreover, manifestations of decline are visible in the reduced importance of the Wallsend Basin and the abandonment of many of the old Tyne-bank collieries. In 1851 an event of both symbolic and geographical importance occurred when the group of collieries which jointly contributed to and were sustained by the Friar's Goose pumping engines at Hebburn Shore withdrew from the arrangement and a progressive flooding of part of the Wallsend Basin ensued [2]. The result was that many of the most famous Northumberland collieries - Bigges Main, Heaton, Percy Main, Willington - were forced to close during the 1850s. Although the area north of the Ninety Fathom Dyke remained important for another century and many collieries were subsequently re-opened to work lower seams, by 1850 the coal industry in that part of Northumberland between the rivers Tyne and Blyth had lost its supremacy forever.

1. <u>Northumberland County History</u>, vol VIII, p 33
2. Ibid.

TABLE 12 : Buddle's synopsis of Northumberland collieries in 1828

Colliery	Lessor	Lessees	Capital outlay (£000)	Labour force	Distance from staith (miles)	Depth of pits (fathoms)	Maximum working capacity (scores drawn in a single shift)	Horsepower employed in: Drainage	Drawing	Leading
Backworth	Duke of Northumberland	Lamb, Waldie, Walker, Maude Hetherington, Taylor and Buddle	60	333	5	54 & 84	70	240	51	108
Benwell	Sir John Swinburne, Adair & Ord	A & W. Surtees, G. Dunn, G.J. Dunn & Buddle	30	234	1½	102	60	130	28	
Burdon Main	Montague	M. Bell, H. Bell, Rob.Bell Rich.Bell & Robson	30	429	1	50 & 89	75	60	75	
Burradon	Rev. Ogle	The Grand Allies	120 (Burradon and Killingworth)	623	6	80 & 82	90	150 (Burradon and Killingworth)	110	36
Killingworth	Pugh, Airey, Bell, Punshon, Bonner & Peareth	"			4	115 & 92	110			
Coxlodge	Ralph Riddle	Bell, R. Brandling, R.W. Brandling & J.Brandling	68	508	4½	90 & 64	125	175	59	24
Cramlington	Storey	Lamb, Scott,Potter & Straker	40	237	7	21	60			
Earsdon	Duke of Northumberland	Clark & Taylor	25½	339	4½	73	70	45	30	none
Elswick	Lord Wharncliffe & John Ord	H. Lamb, J. Lamb & Buddle	27	230	¼	22	89	120	70	
Fawdon	Sir Arthur Hazlerigge	Newmarch	110	318	9¾	50 & 48	110	50	71	92
Heaton	The Grand Allies	Johnson,Row,Clark,Potts, Fenwick,G.Johnson & R.Watson	44½	446	3	80 & 73	105	186	87	
Holywell	Duke of Northumberland	Lamb, Taylor, Clark, Plummer & Buddle	15	217	5	58	70	none	28	none
Percy Main	Duke of Northumberland	Lamb, Waldie, Walker, Maude & Hetherington	100	629	¾	135 & 120	145	215	130	10
Seghill	Sir Francis Blake	Carr, Grey, Bell & Reay	51	281	6	18 & 25	110			
Walbottle	Duke of Northumberland	Lamb, Potter, Jobling & Gray	50	362	2	75 & 88	100	184	58	10
Walker	Corporation of Newcastle	Carr, Potts & Jobling	44½	399	1¼	95 & 85	141	140	90	none
Wallsend	Dean and Chapter of Durham	Russell & Wade	50	614	¾	140 to 104 (5 pits)	175	160	140	none
Whitley	Duke of Northumberland	Clark & Taylor	14	134	2	42	45	65	20	
Wideopen	Sir Arthur Hazlerigge	Newmarch	40	260	8	80	100	70	42	none
Willington	Bell, Brown & Johnson	Bell, Dickson & Johnson	42½	566	2½	105 to 84 (4 pits)	105	278	102	
Wylam	Christopher Blackett	Christopher Blackett	30	242	5	46 & 32	60	65	38	36

Source: NEIMME, Buddle Coll., vol 25, p.16

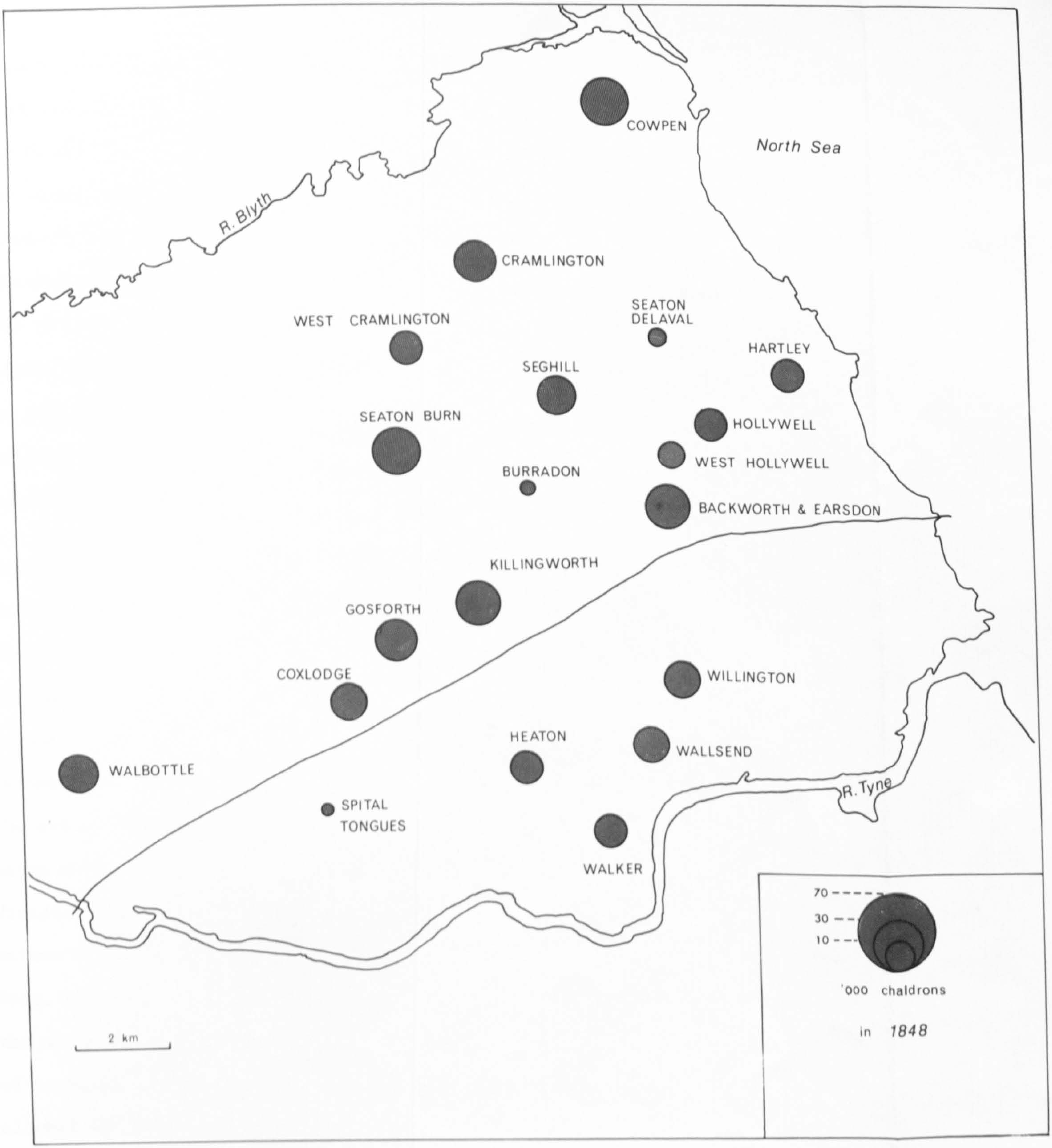

Figure 23 : The distribution of coalmining in 1848

PART TWO : THE INFLUENCE OF OWNERSHIP AND TECHNOLOGY

In part one the process by which coalmining spread from the few localities on the banks of the Tyne where it was important in 1600 to almost all of the coalfield of south-east Northumberland by 1850 has been described. It has been possible, by using a variety of source materials and explanatory techniques, to understand and elucidate in some detail the timing and progress of that diffusion. In addition, many of the geographical factors which controlled the movement of coal-mining, such as entrepreneurship, geology and technology, have entered the explanation incidentally. Part two analyses the roles of land and colliery ownership and of technological change insofar as they affect, and are affected by, the location and progress of coalmining.

It should be emphasised now, however, that there were other influences on the geographical development of coalmining. Two need to be identified here since they represent the medium within which all the other influences on location must be placed. The first was the physical nature of the coalfield and the challenge which it presented to human technology. The second was the market for coal. The former includes the actual land surface and the pattern of accessibility to navigable water which, in relation to the existing level of transport technology, dictated the cost of overland haulage. It also includes the geological nature of all those strata between the Brockwell Seam and the High Main Seam, up to 900 feet (273 metres) in amplitude (see Table 13), which were the arena of underground activity. Superimposed upon this was the pattern of tectonic disturbance, the faulting and folding which had profoundly altered the disposition of the strata and affected the accessibility of the seams from the surface. The spatial development of the industry was a result of the interaction of this physical milieu with man's technical ability to mine coal. But the growth of the industry through time was geared to the increase in his need for fuel. Figure 24 p196 shows the growth in shipment of coal from the Tyne between 1661 and 1828. Nef and others have discussed at length the factors controlling the demand for coal from the time of Elizabeth onwards and it is not relevant to extend the scope of this explanation in that direction. It is worth noting, however, that shipments fluctuated enormously from year to year (the function of Figure 24 is based on five-year running mean values and therefore disguises annual fluctuations). But the extent of annual fluctuation varied during the period as is shown by calculating the relative variability of shipments during each decade (see Table 14). The trend appears to be that the market became steadier towards the end of the period. This was probably due to diversification, with more coal going to industrial markets, which depended less on the caprice of the climate than domestic markets.

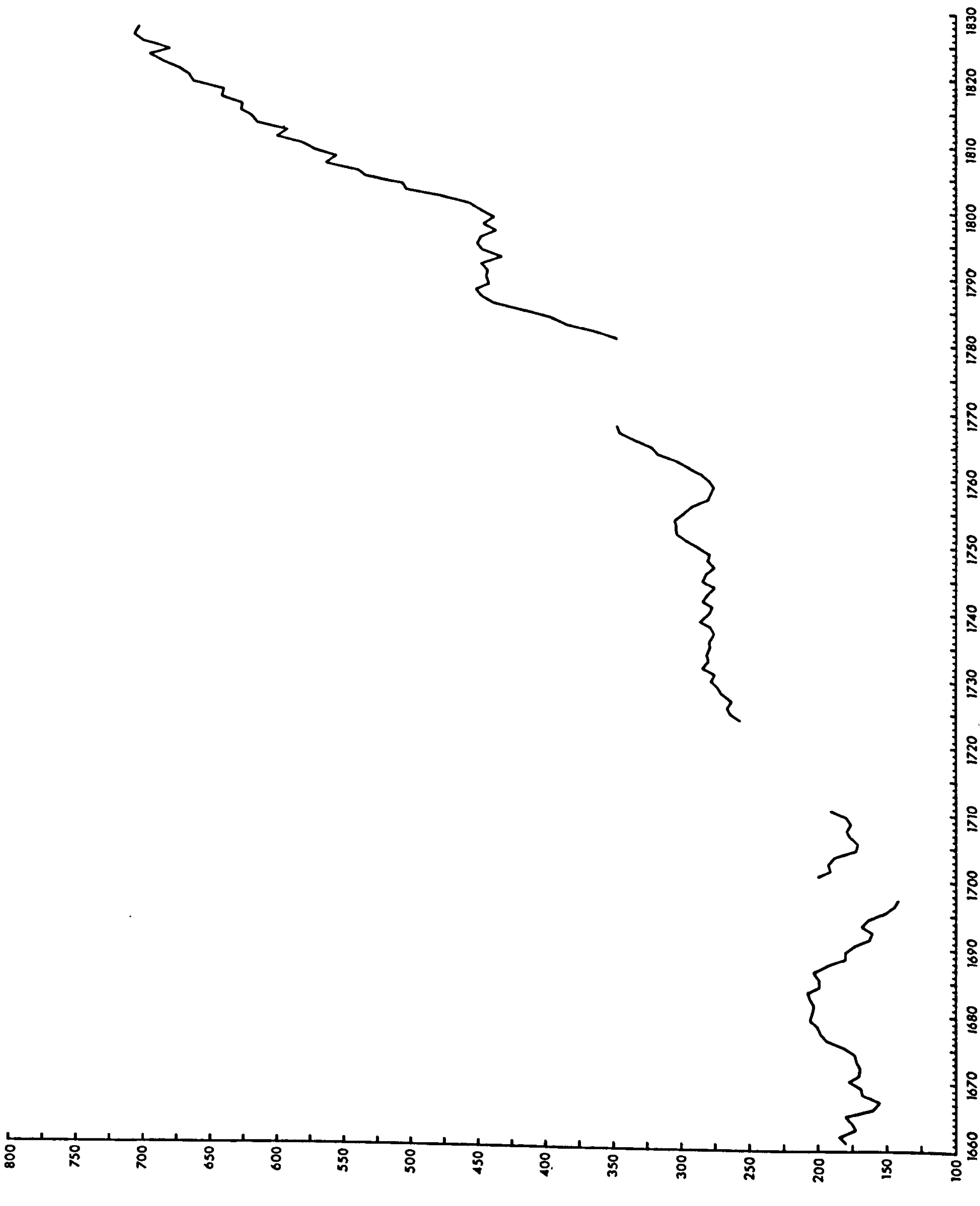

Figure 24 : Vend of coal from the Tyne, 1660 to 1830 (000 chaldrons)

TABLE 13 : The series of coal seams in south-east Northumberland

Seam	Thickness
High Main	6 feet
Metal	1 feet - 6 inches
Stone	1 feet - 6 inches
Yard	2 feet - 10 inches
Bensham	2 feet - 5 inches to 5 feet
Five Quarter	3 feet
Low Main	6 feet
Crow	2 feet - 10 inches
Five Quarter	3 feet - 8 inches
Ruler	1 feet - 10 inches
Townley, Harvey or Beaumont	3 feet - 1 inch
Jetty	2 feet - 2 inches
Stone	2 feet - 5 inches
Five Quarter	3 feet - 5 inches
Three Quarter	2 feet - 6 inches
Brockwell	2 feet - 11 inches

TABLE 14 : The relative variability of coal shipments from the Tyne, 1660-1828

Years	Relative variability (%)	Average R.V. (%)
1661-1669	14.4	
1670-1679	8.5	
1680-1689	7.6	
1690-1697	11.3	
1700-1709	12.5	9.2
1710-1719	I.D.	
1720-1729	I.D.	
1730-1739	3.7	
1740-1749	6.3	
1750-1759	6.0	
1760-1767	8.2	
1770-1779	I.D.	
1780-1789	10.7	6.4
1790-1799	5.8	
1800-1809	6.6	
1810-1819	2.9	
1820-1828	4.5	

I.D. insufficient data

CHAPTER SIX

OWNERSHIP AND MANAGEMENT

There were three main ways in which a landowner could profit from the occurrence of coal beneath, or near to, his property. In the first place, using his own capital he could open a mine and work the coal himself. Alternatively, he could lease the mine to an adventurer for an agreed rent and thus avoid risking his own capital. Less directly, he might profit from an application for wayleave from a nearby colliery by levying a toll or wayleave rent on coal transported across his estate.

In consequence, the extent to which the owner of coal-bearing property became involved in the exploitation of the mineral itself varied considerably. From at least the time of the Grand Lease some landowners showed a preference for leasing mining rights to adventurers, avoiding the risk of capital but still reaping substantial rewards in rents. The great uncertainties surrounding mining argued strongly in favour of this approach. As a result, the Great Northern Coalfield attracted speculators from an early date. The attempt made by Huntingdon Beaumont and his partners to work the coalmines of Bebside, in the first decade of the seventeenth century, is an example of such a venture described by Gray

> Some south gentlemen, hath upon great hope of benefit, come into this country to hazard their monies in coale-pits. Master Beaumont, a gentleman of great ingenuity, and rare parts, advertured into our mines with his thirty thousand (20,000) pounds; who brought with him many rare engines, not known in these parts; as the art to boore with, iron rodds to try the deepnesse and thicknesse of the coal; rare engines to draw water out of the pits; waggons with one horse to carry down coales, from the pits, to the stathes, to the river, &c. Within few yeares, he consumed all his money, and rode

> home upon his light horse.
>
> Some Londoners of late, hath disbursed their monies for the reversion of a lease of colliery, about thirty yeares to come of the lease: [1]

In contrast, other local landowners were prepared to invest heavily in the winning and working of their own coal resources and shunned outside interference. The Delavals at Hartley are just one good example of entrepreneurial aristocrats in Northumberland [2].

The propensity of local landowners to become directly involved in mining coal appears to have diminished after 1760, however, when the advent of deep mining, with resultant rising capital inputs, favoured the emergence of embryonic coal companies. These were larger partnerships than were common in the coal trade up to then and were able to draw on greater reserves of capital. The financial and banking machinery, necessary to spread the risk of failure, was more readily available by then. Moreover, by the late eighteenth century there were more skilled viewers who became, in practice, colliery managers, so that the new capitalists did not need to be experienced or skilled in colliery matters.

6.1 Coalmining as a source of conflict

A great many different kinds of conflict, involving the ownership of property and resources, can arise from the exploitation of mineral deposits. Obviously, the winning, working and transportation of subterranean minerals cannot be achieved without some degree of disruption of pre-existing activities on the surface. Every royalty, before it is colonised for mining purposes, has an established pattern and system of occupance

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1. W. GRAY, Chorographia or a Survey of Newcastle-upon-Tyne (1649), p 86
2. NRO, the Delaval Collection. See my article appended.

which must be disturbed to a greater or lesser extent. This was certainly true of most areas in south-east Northumberland under which mining took place between 1600 and 1850. Moreover, coalmining, by its very nature, is inimical to other forms of land-use. At worst, by obliterating the topsoil in some areas it can make agricultural activity impossible. One agent complained of an area in Tynemouth that the land would "...neither bear meadow nor corn while the world endures" due to the depredations of mining activity in the seventeenth century [1]. In addition, mining subsidence is notorious for disrupting the pattern of surface drainage and undermining the foundations of buildings and other man-made structures. Furthermore, a colliery needs a labour force; it relies on lines of specialised transport; its lifeblood is the large-scale movement of bulky, dirty materials. It is hardly surprising that the sudden commencement of mining operations often provoked fierce opposition in areas where the way of life had changed slowly and imperceptibly over centuries.

The degree of turmoil created by a new colliery varied considerably from one royalty to another. It depended partly on the pattern of pre-existing settlement and partly on the size and nature of the new colliery. In the simplest conceivable circumstances, a proprietor, owning both the royalty and the surface of an estate upon which there was little settlement fabric and which had immediate access to navigable water, could mine coal with a minimum of hindrance and dispute, and without having to pay compensation or rent. Such circumstances did not often arise although, again, the Delavals at Hartley were almost this fortunate. At the other extreme, where the structure of surface ownership was highly fragmented, perhaps with freehold and copyhold lands interdigitally mixed, where access to

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1. Northumberland County History, vol VIII, p 20

navigable water involved passage over a number of other estates, and where adjacent landowners or local property-owners were unsympathetic, the mine operator then had to contend with an array of costs additional to those of actual production.

The physical impact which a colliery had on the surface and, therefore, the extent to which it conflicted with other land-uses also depended upon the type of mining involved. Where the seams being worked were shallow the density of pits on the ground was normally greater[1]. The converse was true where deep coal was being worked.

Before 1600 considerable areas of the Tyne Valley had been affected by mining operations of one sort or another and a few localities had been almost transformed. Since coalmining was centuries old by then many precedents must have been set. Some kind of institutional apparatus must have emerged to accommodate the development of coalmining. Before the Reformation, however, mining had been mainly in the hands of the clergy and the sort of disputes which arose when ambitious, competing entrepreneurs came into conflict may have been relatively rare. But they were not unknown. Benwell was the scene of many early disputes:

> In 1375/6 Richard Scot accused his ... neighbour William Delaval of breaking into his part in Benwell, cutting down trees, digging up coals, driving away cattle to the value of £100, carrying off deer, and taking herons from their nests, carrying away corn and hay to the value of £40, opressing the tenants of his coalmines, John de Chamber and John Whickham, so that they dare not work the mines, and insulting and wounding their servants John Berdene and Roger of Willington.
>
> William Delaval said in defence that the lessees of the mines had

---

1. But the density of pits was not simply governed by seam depth. Technology played a very important role. See p 308

> damaged his herbage by their mines, and that in compensation John de Chamber had given him a pipe of wine, and John of Whickham 8 marks, of their own free will, and for the rest he claimed right of way in the enclosure which Richard Scot had made.
>
> The Jury, formed after many delays, awarded damages to Scot, including damage to the heronry, and found that Delaval had not right of way through the park [1].

Although a framework of legal precedent existed by 1600, such was the variety of circumstances in which mining operations took place that many disputes occurred during the seventeenth century. Whether such disputes ended up in the Court of Chancery usually depended upon the ability of the two sides to reach a mutually beneficial compromise. Potentially the profits from coalmining were so great that only rarely did a party suffer absolutely, although the wranglings which were pursued over relative advantage were almost endless.

Sometimes the parties involved were not amenable even to the law. In 1669 Peter Watson, yeoman of Scotswood, served Mark Errington with a writ,

> ... by which injunction the said Deft. was injoined to permit and suffer the Complts., his Maties. farmers of certaine coalmynes and colliery in Denton ... peaceably and quietly to have, hold and enjoy the wayleaves and staithroomes belonging to the same colliery, as they had done for the past three years ... and at the serving of the said injunction he, the said Deft. did, in a contemptuous manner, slight the same, bidding this Dept. serve the same injunction upon a horse that was then upon the ground near [2].

By the seventeenth century the licence to mine coal in the recognised

1. Quoted in the Northumberland County History, vol XIII, pp 217-8
2. PRO, E 134 22/23

coalmining districts was established by time, precedent and tradition. Thus in the manor of Chester le Street in County Durham the

> ... right, usage, custom and priviledge of ... the Lord Bishop of Durham and his lessees to win and work the coalmines and collierys under the inclosed coppyhold lands and grounds ... is not new or of late standing but hath been anciently used and enjoyed time beyond all memory [1].

It was the very antiquity of the privilege which justified it. Unfortunately rights established by precedent were seldom exactly defined and many disputes arose concerning the precise nature of existing licence.

In seventeenth century Northumberland the ancient coalmining royalties along the banks of the Tyne west of Newcastle were the scene of many quarrels involving the possession of rights and resources. During the previous century, by means of the Dissolution of the Monasteries and various acts of attainder, the crown had gained nominal possession, both partial and complete, of large areas of coalbearing property in the county. Although direct royal participation in the industry was not attempted [2], both the government and the monarchy were aware that the potential revenue from the coal trade was considerable. Duties on coal shipped from the Tyne had been levied since 1379 [3]. A commission investigated the state of the King's coalmines in 1611 clearly with the intention of establishing the extent to which rents were in arrears [4]. It was far easier, however, for the crown to levy duties on coal shipped from the ports than to keep

1. PRO, E 134 9/Geo 2/East 10
2. Although Charles I attempted to gain control over the flow of coal to London. See T. J. TAYLOR, op. cit., pp 14-15
3. NEIMME, Bell Coll., vol I, p 457
4. PRO, E178/5037

tabs on actual coalmining operations in all of the far-flung estates in which it had an interest. Evasion of crown rents was probably ~~fairly commonplace~~ widespread but occasionally there was a clamp-down, ~~as~~ such as in 1611. Two decades later, in 1631, an inquiry took place at Benwell to discover

> ... what arrearage of rents ... are now or were heretofore due, arrear and unanswered from ... 1571 ... until the fourth year of the reign of the King's Majestie that now is ,.. in respect of certain coalmines and every or any part thereof, called by the name of Stumplewoodhead, Crosseflatt and the Meadowfields [1]

The crown owned two-thirds of Benwell. The owners of the other third had worked the colliery vigorously during the previous two decades, apparently without paying the monarch his due.

6.2 Agriculture versus industry : The need for compensation

Such disputes arose from the apportionment of wealth. The other main source of conflict was compensation. As seen above, the right of farmers and property-owners to be indemnified for loss and damage as a result of coalmining was established at an early date. By the seventeenth century the apparatus for such indemnification was fairly refined. In the manor of Chester-le-Street, according to one Ryton waggonman

> ... it hath been usual and customary for the Bishop of Durham and his lessees to bore for, digg, open, winn and work the collieries and coalmines lying and being within and under the inclosed coppyhold lands ... and carry away the coals won, wrought and gotten thereout, paying reasonable damage and satisfaction to the respective owners and occupiers ... for the spoil and damage occasioned thereby to the herbage or corn thereof, that is to say ten shillings for breaking ground or sinking each pitt, three

1. PRO, E 178 5996

> pounds for heaproom of each pitt, three pence a yard for every yard in length for laying waggonways (the usual breadth) from such collieries over and along the pasture grounds and four pence a yard for damage of laying waggonways over the corn and meadow ground ... are and have been paid yearly ... during all his knowledge and time beyond all memory ...[1]

The compensation of farmers whose lands had been affected by the depredations of mining activity was thus institutionalised by custom. The extent to which this system worked fairly, with justice for both sides, is difficult to assess. Lease-holders were in a rather more vulnerable position than freeholders, however, since they had no right to withold permission for mining to take place under their lands and had to rely on the fair-mindedness of the lord of the manor. Moreover, monetary compensation was not effectively inflation-linked and, since fertility did not return immediately to the soil after mining, and ~~therefore~~ after compensation had ceased, it seems likely that agriculture suffered in the long run. It is not surprising therefore that some farmers preferred to take compensation in a different form. The system which had evolved at Elswick is a remarkable example. Here farmers received no recompense

> ... for damage or spoils of ground occasioned by reason of digging and sincking of pitt or pitts there, or by reason of wayleaves for leading the coals ... with wains and other carryages from the pitt or pitts unto the staith called Elswick staith [2]

Humphrey Gill was a tenant farmer of lands in Elswick from 1663 to

1. PRO, E 134 9/Geo 2/East 10
2. PRO, E 134 32/Chas 2/Mich 30

1678 and during that time

> ... never had satisfaccon for any pitt or pitts suncke in the said ground though sometimes pitts were suncke in corne ground [1]

Although the farmers of Elswick accepted no direct financial compensation for damage or inconvenience, they had instead

> ... the sole benefit and advantage of the leading and carrying of the coales wrought out of the said colliery from the several pitts unto the staith ... in lieu and satisfaccon of all damages sustained by the wroughting of the said colliery [2]

There were ten farms within "the towne of Elswick" and each farm

> ... had and kept two waines which were imployed about the leading of the coles ... and ... there was paid and allowed unto the said owners of the said lands, their farmers and tenants, for the leading of the said coles severall rates and prices according to the distance of the pitts from the said staith (viz.), for every fother led from the pitts which was on the backe of the staithman's house three pence p. fother and for every fother of coales led from any pitts betwixt the hedge hedging to Moder's Hill and another hedge adjoining the highway to Benwell fower pence per fother, for any pitts betwixt the said way and another highway called the Wall Way five pence per fother, and for every fother ledd from any pitt or pitts in any place whatsoever to the northward of the said Wall Way the sume of six pence per fother [3]

Clearly, at some time, the farmers of Elswick had adopted an acquiescent

1. PRO, E 134 32/Chas 2/Mich 30, deposition of Humphry Gill
2. Ibid.
3. Ibid., deposition of Cuthbert Turner

philosophy. This system which prevailed at Elswick in the middle of the seventeenth century represents a remarkable reconciliation of the farming interest to the realities of large-scale coal exploitation. It was certainly in their interests to accommodate such realities:

> the leading and carrying of the coles by the sayd owners, farmers and tenants of the said coppyhold lands ... was very advantageous and beneficial unto them, for ... a coppyholder, his tenant or farmer and his or their deputy or servant going with a wayne and carrying coles wrought out of the sayd cole-mines from the several pits to the staiths would earn or gaine eighteen pence more in a day by carrying of coles than in any other place ...
>
> ... and sayth that if such tenants ... had not a minde to performe the carriage themselves then they always lett their carryages or cartes, proportionable to the farme, to any whom they pleased and the usual benefit that such coppyhold owner or tenant had by letting out his carriage was fifty shillings a waine and twenty-five shillings a carte per yeare [1]

Another deponent stated that the profit gained by the farmers of Elswick

> ... hath been generally a thirde parte in three and sometimes more than what others doe earne and gaine by leading of coales in any other place that he knowes of on the north side of the river of Tyne [2]

This was a case in which the priority of coalmining over agriculture was accepted despite the obviously detrimental effects of the former on the latter:

1. PRO, E 134 32/Chas 2/Mich 30, deposition of Humphry Gill
2. Ibid., deposition of George Barkas.

> pitts have been suncke in some of the corne grounds whilst corne was standing and growing ... and the coles have been ledd and carryed with cartes and carryages through the said corne grounds ...
>
> the owners or farmers of the said coalmynes and colliery have builded hovells and shedds upon the lands and grounds there necessary for their workmen [1]

There ~~do~~ seem to have been occasions, however, when the extent of destruction exceeded the advantages which ~~the~~ farmers had gained. It is worth recording in some detail one witness's observations as to how the sense of injustice arising from such an excess was removed:

> about twelve or fowerteen yeares agoe the owners and farmers of the said colliery sincking downe pitts in corne grounds where corne were growing ... Sir Ralph Jennison ... did stopp and hinder the carriage of the said coale owners requiring satisfaccon for spoile of grounds and that thereupon the said Sir Ralph Jennison and ... Thomas Ledgard's late father ... goeing aside together had some private discourse betwixt themselves but what the same was this deponent knoweth not but saith that from that time ... the said Sir Ralph Jennison ...(and) William Wallis, who was then alsoe interested and concerned in the said colliery, had all their fire coales which they burnt and spent at their dwelling houses in Elsewick from the coalepitts in Elsewick aforesaid free [2]

Normally the farmers paid the standard 'landsale' price for coal.

This system, by which farmers were given the benefit from transporting coal from pithead to staith in compensation for loss of agricultural

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1. PRO, E 134 32/Chas 2/Mich 30, deposition of Bryan Vertus
2. Ibid., deposition of Charles Newton

productivity, was abnormal and may even have been peculiar to Elswick. Humphrey Gill claimed to know

> ... the owners, tenants and farmers of collieryes and colemines within severall mannors and in particular within the Manors of Benwell, Whickham and Ryton

and stated that these

> ... have for many yeares last past payd and made recompense and satisfaction to the coppyholders, tenants and farmers within the said particular manor for spoil of ground in sinking of pits, leading of coles building of staith, hovells and lodges and other damage done in and upon the sayd coppyhold lands [1]

In a memorandum of 1650 Mark Shafto of the manor of Benwell, adjacent to Elswick and in many ways similar to it, wrote,

> I am of opinion that the grounds of the coppyholders cannot be opened or brocken, or any other spoyle or loss done to the said grounds, without satisfaction or recompence to be made unto them by the owners of the mines for such loss and spoyle, for otherwise the coppyholders should pay their rent and have no profit at all, which cannot be done by any grant, 'tis true if the mines and grounds had been both in one hand in Demaine by such a grant of the mines wayleave might have been granted but it is not so in this case ... [2]

The question of compensation for property-owners and tenants was obviously vexatious. The impact of mining was so various that there was no possible

1. PRO, E 134/32 Chas 2/Mich 30, deposition of Humphry Gill.
2. NRO, MBE/III/1

panacea. The old established Tyne-bank collieries had evolved codes of practice which, with a degree of flexibility, were usually accepted for better or worse. It is clear from what has been said above, however, that there was no universally established convention. If a dispute between the mining and farming interests reached deadlock, then the parties often ended up in court. Increasingly, however, a code of practice was established by which two parties at loggerheads would call upon a team of impartial arbitrators to devise a just and amicable solution.

6.3 A dispute at Hartley

It is worth examining in some detail one such case which arose at Hartley in the first quarter of the eighteenth century. The manor had been enclosed about a century previously and one of the large mixed farms was leased to Charles Green. It comprised "about one halfe the manor of Hartley". In 1695 John Rodgers, a well-known Tyneside colliery speculator, began working Hartley Colliery with a lease from Sir John Delaval, owner of the manor. In succeeding years the colliery was prosecuted vigorously causing a considerable impact on some of Charles Green's fields.

> There are eight pitt rooms in the ... South Field, ten or eleven pitt rooms in the ... Thistley Field, five or six pitt rooms and staples in the ... Breardean Burn Field and thirteen or fourteen pitt rooms or staples in the ... Flatting Pasture ...[1]

This appears to have been prime agricultural land. The fields were "all extraordinary good ground". As a result the

1. PRO, E 134/5 Geo 2/Hilary 12, deposition of William Howell

> ... farm was much damnifyed by the said coles being ledd through the same
>
> ... several pitts were sunk and wrought in the ground belonging to the ... farm when corn was growing thereupon and great quantities of the ... corn and grass were frequently eaten and distroyed (sic) by the cattle belonging to the carryages imploy'd in leading coles ... [1]

Clearly, Green was entitled to some degree of compensation. Unfortunately, the parties involved disputed the exact amount which was due. The system of arbitration seems to have failed. In 1716 Rogers appointed Henry Hudson and John Atkinson while Green asked Robert Bailife and Jacob Ruther to assess the damage to the farm from the colliery; " ... they came to no agreement". Six years later another arbitration was attempted. Four different assessors were engaged to price the devastation of the previous twelve years; " ... they also did not agree therein". One estimate of the compensatory payment outstanding when the case came to court in 1732 was £417. Even when the Rogers family surrendered the lease in 1725 and Sir John Delaval carried on the colliery himself he could not agree with Green, his own tenant, upon a fair rate of compensation. Both Delaval's own arbitrator and James Meaburn, acting for Green, agreed that damage amounting to between £13 and £14 per year had been caused by the colliery

> ... in each of the two years that ... Sir John Delaval had the colliery in his own hands but that Sir John Delaval would only pay nine pounds for each of the said years [2].

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1. PRO, E 134/5 Geo 2/Hilary 12, deposition of William Howell
2. Ibid.

Evidently, there was a lack of any formula or clear guidelines by which the amount of compensation due to a farmer could be calculated. Agricultural land varied in quality and productivity. Mining activity varied in the extent to which it mutilated the biosphere. In the absence of a traditional basis, or acceptable precedent, or bribery, farmer and miner could appoint a team of arbitrators. Unfortunately, doubt could always be cast on the impartiality, individual or collective, of the men appointed so there was always the chance that a dispute would pass to the courts.

Overall the impression gained is that agriculture suffered in spite of compensation. Charles Green was a substantial farmer. A neighbouring farmer in Hartley valued Green's farm at £336 per year and his own at £60. Green could afford to go to the Court of Exchequer for justice. There were almost certainly others who could not.

6.4 Compensation and technological change

One factor which increasingly undermined accepted norms of compensation in the seventeenth century was technological change. Before then mining had been a small-scale and relatively simple physical process. The arrival of permanent way for surface haulage and of more sophisticated pumping machinery increased the impact of coalmining on the landscape. Such change provoked the commissioners investigating copyholders' rights at Chester le Street to ask

> ... are ... waggonways of modern or late, and how late, invention ... how long have the same been used ... is it usual in laying such ways to cast, dig or throw up trenches or moulds and great quantities of earth and soil and ... to fix great quantities of timber and stones in and upon the ground and ... to take away

great quantities of soil in order to levell such ways [1].

At Denton, as early as 1610, a stream which

> ... did in former tymes pass by the west of Henrie's orchard and soe between the ... dike and a place called Hogells eastward where they used to hang their fishing netts
>
> ... for the makinge of the coalmynes more easy and a fytter passage and to build staythes it hath been diverted and made to fall straight southwards to the water of Tyne [2].

For men who were not conditioned to accept these kinds of change as normal such upheaval of the rural landscape was of profound concern. No farmer could feel safe for none knew what mineral wealth existed, or did not exist, beneath or adjacent to his fields. Moreover, the normal legal apparatus which dealt with mining, because it was based on precedent, could not easily be geared to cope with new technology.

This natural conflict between traditional norms on the one hand, and technological change on the other, is perfectly highlighted by a case in 1731 concerning wayleave from the manor of Beamish, in County Durham, to the River Tyne. The origins of the conflict can be traced to some sixty years before, in 1671, when Thomas Wray, owner of the manor and the adjacent common of Tanfield Moor, sold the surface to William Christian but retained the coalmines " ... with convenient wayleave for leading the coles" [3]. The separation of the ownership of surface and mine laid the seeds of the future conflict. In 1690 Wray sold the

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1. PRO, E 134/9 Geo 2/East 10
2. PRO, E 134/8 Jas 1/Trin 1
3. PRO, C 11/690/12

colliery to George Pitt while the manor devolved into the hands of Sir John Clavering. Meanwhile the progress of technology was running its course;

> Some short time before the said sale to Mr Christian a new method was invented for carrying coles to the river in large machines called waggons, made to run on frames of timber fixt in the ground for that purpose and since called a waggon-way ...
>
> These sort of ways were only made use of for a small number of collieries in 1671 [1].

In 1712 a waggonway was constructed linking Beckley, Bucksnook and Linz Collieries with the Tyne and George Pitt agreed with the owners of the waggonway to build a branch serving his own colliery at Beamish. The description of its impact (a remarkable precursor of the transport revolution to come) is worth dwelling upon. The branch was about three-quarters of a mile in length

> ... and about 1160 yards thereof is laid double, the one way being for laden wagons going from the colliery and the other for empty ones returning; and it is about eight yards wide between the inside of the gutters, which are made for the most part on each side of that way, but throughout on one side; and such gutters are commonly two foot broad and half-a-yard deep ... and in other places where the ground is not level there are great batteries and banks of earth raised to level the same, and in other places the ground is pared and dug, and the earth and soil taken away for a great breadth for making such batteries ... The appellant also made three bridges and two batteries upon the said Moor to lay his said way upon; one of which bridges is 40 yards long and 5 yards high ... and the batteries of earth for making those bridges are about 25 yards broad at the bottom

1. PRO, C 11/690/12

> ... and these cuts, gutters, bridges and batteries are very dangerous for the cattle which depasture upon the said moor, and hinder their passing from one part of it to another, and the appellant in making and using that way does much more damage to the said Moor than the leading of his coles by carts and wains would occasion [1].

William Davison owned Beamish before it was purchased by the Claverings and it was he who first complained of the effects of the waggonway. He preferred, however, to sell the estate for £4000, and it was the Claverings who took the case to the Court of Chancery. They contested the right of George Pitt to build a waggonway under the terms of the lease. Pitt's defence was that 'wayleave' was a general expression which included the right to build permanent way;

> that the soil of Tanfield Moor is very spungy and that coals would not be carried over the same in carts and wains above six months in the year; but by waggons they may be carried nine months in the year
>
> ... that the said waggonway is of less damage to the herbage and of less prejudice to the respondent ... than any other method of carriage, in regard such waggonway is one single track, and all other carriages go and spread over as many different parts of the said Moor as persons carrying coals think fitt [2].

The initial verdict was in favour of the Claverings but Pitt, playing for time, lodged an appeal. This is a clear case in which technological change had perplexed the normal process of legal transaction.

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1. PRO, C 11/690/12
2. Ibid.

6.5 The effects of mining subsidence

As well as the damage which mining caused to cultivated land and pasture there were also many cases of its detrimental effects on buildings. Consequently this was another source of conflict between property owners and mine owners. In 1745 a team of viewers

> ... were appointed to arbitrate between William Coulson of Jesmond esq. and Matthew White of Blagdon and Matthew Ridley of Heaton esqs. as to the shakings and cracks in the Mansion House, offices and garden walls ... and in other houses of the said William Coulson in Jesmond ... caused by the irregular and undue workings of certain coal-pits by them, the said Mr White and Mr Ridley [1].

In fact it was part of Charles Green's case against the owners of Hartley Colliery that his buildings, as well as his farmland, were suffering damage. In 1721 Isabella Stewart, the wife of a Hartley pitman, was visiting Elinor Cook, whose house adjoined a byre belonging to Charles Green and contained some of his cattle, when it became evident to them that the byre was about to collapse. She managed to save the cattle by informing Green. And yet

> ... she observed the complt. (Green) to take great care in thatching and repairing all the houses belonging to the said farm.

She could also recall

> ... another house on the south side of the said town (Hartley) wherein one William Smith did live was new thatched and the timber thereof prop'd about eighteen months ago notwithstanding

1. NRO, Ridley Coll., ZRI/35/22, p 148

which the said house fell down soon after [1].

In the case of damage to buildings and other man-made structures through subsidence, as opposed to the direct destruction of agricultural produce or potential, the role of mining was less easy to quantify. The relationship between coal-workings five hundred feet underground and the collapse of buildings on the surface was more tenuous. Was subsidence entirely to blame? Or had the owner of the building failed to keep it in an adequate state of repair? Moreover, at this date the way in which mining subsidence occurred was rather less clearly understood than it is today. Even with impartial arbitration it was obviously difficult to determine both the extent and nature of the miner's liability.

6.6 Leases and rents

Even if he eschewed the role of miner the coal-owner was able to control, to some extent, the way in which his coal was exploited through the terms of the lease by which he transferred working rights to another party. As time went by lessors tended to increasingly limit the lessee's freedom of action by the terms of the lease. While it was in the former's interest that his mineral wealth was exploited profitably and effectively it was also desirable that the normal functioning of the estate should be minimally disrupted.

The colliery lease defined the extent of the entrepreneur's rights. It had a fundamental effect on the development of a colliery and its form is, therefore, worth examining in more detail. The clauses themselves varied, both through time and from colliery to colliery but the general order remained fairly constant, as did the interminable pedantry of the legal jargon employed.

1. PRO, E 134/5 Geo 2/Hilary 12, deposition of Isabella Stewart.

The initial clauses were usually concerned with a general delimitation of lessees' rights

> ... to dig, sink, ridd, winn, work and make ... pitts ... trenches ... groves ... and to drive ... drifts, watergates and watercourses ... for winning, working and getting coals ... and ... for the avoiding and conveying of water and styth out of the (mine) [1].

The lessee was also normally granted " ... sufficient and convenient ground roome and heape roome".for depositing both coal and mining spoil and also the right to erect " ... engines, houses, stables, hovells, lodges or shedds" for the accommodation of machinery, horses and men. Sometimes a lessee would also ask for a lease of farmland adjacent to the colliery where feed might be produced or pasture provided for the colliery horses. For instance, one proviso of a lease of Benwell Colliery was that the lessee should " ... have 40 acres of ground as near as possible to the winning at a reasonable rent" [2].

Having defined these rights the lease then went on to describe the terms under which they were transferred. Firstly, the length of time the lease was to run was stipulated. This varied considerably, as is evident from Table 15. In the seventeenth and early eighteenth centuries it was common practice to grant very long leases, often of 99 years, Such practice was at the root of the Grand Allies' attempt to monopolise coal-bearing land. Although the lease of Longbenton Colliery was granted to the Allies in 1735, for instance, they made no attempt to win the colliery during the first six years and re-negotiated the lease in 1742 [3].

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1. NRO, Ridley Coll., ZRI/6, a lease of Plessey Colliery (1708).
2. Newcastle Central Library, Colliery MSS, vol B, p 60
3. NEIMME, Watson Coll., 10/51 ; shelf 18, Richard Peck's Viewbook

TABLE 15 : The terms of colliery leases; some examples between 1722 and 1832

Colliery	Date	Duration (years)	Certain rent (per year)	Certain Quantity (in tens)	Tentale
Kenton	1722			600	0 - 7 - 0
Longbenton	1735	99			
		first 6	400	584	0 - 13 - 8
		next 6	600	878	0 - 13 - 8
		next 28	900	1317	0 - 13 - 8
		remainder		1200	0 - 15 - 0
Coxlodge	1737	21	50	100	0 - 10 - 0
Willington	1778	51	400	533	0 - 15 - 0
Chirton	1785	31			1 - 2 - 0
Kenton	1790	31	500	571	0 - 17 - 6
Cowpen	1795	39	400	666	0 - 12 - 0
Walker	1796	41	500 (HMS)	571	0 - 17 - 0
			250 (LMS)	286	0 - 17 - 0
Coxlodge	1796	31	500	555	0 - 18 - 0
Murton	1798	21	800	600	1 - 6 - 8
St Anthony's	1802	21	300	400	1 - 10 - 0 (HMS)
					0 - 15 - 0
Chirton	1804	31	1000	667	1 - 10 - 0
Walker	1809	7	1000	667	1 - 10 - 0 (HMS)
Kenton and Coxlodge	1817	21			
		first 10	1343 - 10 - 0	1250	1 - 1 - 6
		remainder	350	200	1 - 15 - 0
Cowpen	1818	700 acres	400	667	
Walker	1818	31	600	686	0 - 17 - 6
East Benton	1820	41			
		first 5	200	200	1 - 0 - 0
		remainder	300	300	1 - 0 - 0
Heaton	1821	21	500	370	1 - 7 - 0
Seghill	1823	19	250	250	1 - 0 - 0 (750 tens)
					0 - 16 - 0 (above 750)
Little Benton	1831	31	300	300	1 - 0 - 0 (HMS)
					0 - 17 - 6 (other)
					2 - 0 - 0 (barriers)
Longbenton	1832	31	750		2 - 0 - 0 (HMS whole)
					1 - 5 - 0 (HMS pillars)
					1 - 2 - 6 (other)

The colliery rent had to be paid, of course, but this simply covered coal which could be worked at any time during the lease. As time went by, however, coal-owners began to offer shorter leases and, after the middle of the eighteenth century 21, 31 or 41 years seems to have become the norm. The alternative to stipulating a duration was to define an areal extent (as in the Cowpen lease of 1818). One advantage of this was that the coal-owner could restrict, to some extent, the impact of mining within his estate.

Invariably the colliery lease then stated a 'certain' yearly rent, either payable immediately the lease was signed or with a proviso which allowed the lessee two or three years to make a winning before the rent was due. Linked to the 'certain rent' was a 'certain quantity' which the rent enabled the lessee to work. For any coal in excess of that quantity a 'tentale' rent had to be paid. These figures were negotiable. If the quality of the coal within his royalty was proven, if the winning promised to be simple and trouble-free, if the price of coal was currently good, and if trade was brisk, then the owner might expect to make a deal favourable to himself. Even if adverse conditions prevailed the owner was in the happy position of knowing that in the long term the demand for coal would increase.

That the market was becoming increasingly sensitive to the varying quality of different coal seams is also evident from Table 15. The High Main Seam was obviously prized. The effects of inflation are also clearly discernible. A rent of £200 at Kenton in 1722 licensed the working of 600 tens while £200 at East Benton a century later permitted the working of only 200 tens. The structure of some leases reveals that owners were aware that inflation could erode their advantage. Indeed this argued powerfully for the reduction of the duration of a lease to the minimum.

Clearly the terms under which leases were granted varied considerably. Generally, leases became more rigorous in the limitations they placed on the adventurer. Increasingly estate owners were unwilling to countenance wholesale disruption, even destruction, of the surface merely to reap the transient profits of a phase of coalmining.

6.7 Limiting the impact of mining

In granting a lease of Chirton Colliery in 1785, Edward Collingwood insisted that the lessees should undertake " ... not to sink pits or make roads in the field fronting the Mansion House at Chirton or thro' any gardens, lawns or orchards" [1]. Where the surface and the royalty were possessed by different parties the owner (or lessee) of the surface was normally anxious to place precise limitations on the freedom of action of the miner. This was certainly true in the early nineteenth century when the Duke of Northumberland wished to lease his colliery at Backworth but was frustrated by Ralph William Grey, an influential copyholder of the manor. In 1803 George Burdon, with a lease from the Duke, began the preliminaries to working the colliery. But Grey "... laid off the borers after boring 6 or 7 fathoms and plugged the hole" [2]. It may have been that political rivalries exacerbated the dispute (the Greys provided the Whig Reform Bill prime minister, while the Percies were Tories). At any rate, Grey was certainly unwilling to brook any damage to his land. Undaunted, the Duke granted a new lease to Waldie, Maude, Walker and Lamb, in 1812 and by 1815 a winning was in progress. Grey then took the case to court with the result that

... Mr Justice Bailey laid it down that to the Lord of the Manor

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1. NEIMME, Watson Coll., 9/18
2. NEIMME, Buddle Coll., vol 14, p 16

> belonged the mines in the copyhold estates in the manor but then that lord could work only underground; he could not break the surface without the consent of the copyholder unless he could prove his right by custom [1].

This was a significant conclusion. Here coalmining appears to have been completely, if temporarily, thwarted because Backworth was a new colliery which did not have the institutional flexibility, established by precedent, of the old Tyne-bank collieries.

Grey was willing to take his advantage to the extreme. He asked John Watson, who was probably then the foremost colliery expert in the area, to calculate the

> ... expense the lessees of Backworth Colliery will be put to in the event of their having to remove the New Winning ... with the whole of the buildings and works ... and rebuild the same upon some other situation where it is presumed the Duke of Northumberland can grant them the power of doing so, on some adjoining ground to the Backworth Estate bounder, so as to enable them in a partial manner to work the coal-mines under the same [2].

In other words he was suggesting that they should remove the plant of the partly won colliery to an adjacent royalty, owned by the Duke, and work the Backworth coal by outstroke. Obviously this would have represented an enormous escalation in the cost of underground transportation. John Watson's estimate of the cost of removal was £5,375-9-0,

> ... made upon the supposition that they (i.e. the lessees) work

1. NRO, Ridley Coll., ZRI/35/22; NEIMME, Buddle Coll., vol 3, pp 1-8
2. Ibid.

> the beforementioned tract from a winning to be made in a nook on the north side of the Tynemouth Shire Moor, and not permitted to sink any pits upon the Backworth Grounds ... [1]

and his conclusion was that the Duke and his lessees

> ... will not be able to work the coal (at least to profit) under the north part of the Backworth Estate which contains 700 acres,

This would leave only 65,540 tens workable.

The Duke of Northumberland was so frustrated by this dispute that by 1819 he appears to have sold the Backworth coal royalty to his entrepreneurial adversary [2]. Grey then proceeded to stipulate the strict conditions under which he would allow the lessees of Backworth Colliery to continue their winning:

> Lessees not to sink pits, lay waggonways or make buildings or erections within the red line drawn upon the plan of the township of Backworth; nor to build outside the said line any erections ... except 4 houses, a stable and smith's shop at each pit ... and which buildings are to be covered with slates or blue pantiles ... not to permit any of the small coals to be deposited so as to take fire upon any part of the grounds of Backworth ...
>
> Lessees not to make or repair any boilers upon the Grounds at Backworth during the time Ralph William Grey or his family may be residing there ...
>
> Lessees not to suffer their agents or workmen to keep any dogs,

1. NRO, Ridley Coll., ZRI/35/22; NEIMME, Buddle Coll., vol 3, pp 1-8
2. NRO, Ridley Coll., ZRI/35/22, pp 196-219

> asses and poultry upon the premises under penalty of £10 for every dog or ass and the forfeiture of poultry to the lessors.
>
> A blacksmith's shop to be built on the east side of the Engine Pit, and the present shop to be used for any other purpose but no fire to be kept in it.
>
> Lessees to provide gates, etc. for any breaches they may make in the hedges ...
>
> Lessees to reinstate all damaged ground within 12 months after the expiration of the term ,.. [1]

As the area of active coalmining spread away from the Tyne and into rural Northumberland, landowners were less willing to countenance the kind of uncontrolled despoliation which had occurred near the river. Inserting clauses such as those above into colliery leases was a fairly effective means of at least reducing the serious environmental consequences of the industry. It seems likely that such policy led to important changes in the kind of impact which mining had on the landscape, as well as in the nature of the mining process itself.

6.8 Competition and co-operation: the need for regulation

The dispute between Grey and the Duke clearly affected the timing and nature of mining developments at Backworth. There were many disputes among the coal-owning gentry and their collective impact must have been considerable. Figure 6 p44 shows a hypothetical concatenation of decision-making stages in colliery development. The negotiation stage was clearly fraught with the possibility of dispute and deadlock. A failure of decision-making at this stage could disrupt and deter coalmining. Dispute was latent in the competitive capitalism which was the motive

1. NEIMME, Watson Coll., 9/2

force behind industrialisation. But the coal-owners were never simply competitors in a game, the aim of which was to maximise profit by securing the largest possible share of the market. The coal industry was much too unstable for that. And yet it was not until 1771 that internecine competition was formally abandoned and a lasting system of regulation adopted [1]. Before that the relations among the coal-owners were a strange blend of competition and co-operation, cleavage and combination.

During most of the seventeenth century the inner circle of the Company of Hostmen had dominated and monopolised the Tyneside coal trade. By the end of the century the influence of the society seems to have declined and been replaced by a narrower clique, the Grand Alliance. Entries in the Grand Allies Minute Book suggest that after 1726 there was some attempt at a corporate regulation involving most of the main coal-owners [2] but this appears to have broken down in 1731;

> the coal-owners did not agree among themselves ... it was begun by one gentleman first and others followed [3]

George Bowes, one of the Grand Allies, " ... said he would drop his coals till they were weary of selling rather than pay the premium". The price of coal fell from 12s to 9s 6d per chaldron leading to a period of competitive strife and culminating in the Parliamentary enquiry of 1738. It was during this period (although it had been evident for some years before) that the influence of oligarchical monopoly was most evident. Sir James Clavering was one of the owners at odds with the

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1. H. S. JEVONS, The British Coal Trade (1915), pp 315-316
2. See pp 99-105
3. NEIMME, Buddle Coll., vol 14, p 266

Grand Allies. He observed that

> ... these people who are the Grand Allies have bought the ground at a great rate to stop up the wayleave: I wrote to Mr Bowes to know upon what terms he would part the wayleave, and he said he would not give an answer till he saw Sir Henry Liddell and Mr Wortley [1].

He listed some five collieries which the Allies "... by great expence, have stopped up". The Allies had secured tracts of land which lay between the Tyne and the collieries of their competitors and refused to grant wayleave across them. For these 'negative ways' the Allies had to pay 'dead rents'; "... great rents ... which amount to not less than £5,000 a year".

As waggonways decreased the cost of overland haulage collieries more distant from the river were beginning to compete with the older river-side pits, most of which were owned by the Alliance. According to Clavering

> ... Because they lie nearer the surface, mine lie but from 6, 8 to 10 and 15 fathoms deep, those near the river are much deeper and the cost of sinking and drawing is much more for those collieries.

The Allies, fearing that their mines would have to compete with a deluge of cheap coal from shallower pits, attempted to maintain their dominant position by depriving the new pits of access to navigable water.

The 1730s appear to have been a period of particularly intense rivalry.

1. NEIMME, Buddle Coll., vol 14, p 274

A letter from Richard Ridley to Nicholas Burdon in 1736, concerning salt pans and shipping facilities, shows its potential for antagonism:

> I have yrs of ye 7th advising you had agreed with Mrs Johnson for her pans and premises at £14 per pann per ann. on a lease of 15 years on which I congratulate you - since whereby the dispute for using the key (sic) for ballast must be ended ... I am glad you and Mr Peareth did not agree for as I (told) you he deserves no convenience I can hinder him of, for instead of justice he renders me ill-will and malice, so pray do not let him the key on any terms. I would much rather submit to paying half of repairing the key [1].

But hostility and alienation in one relationship contrasted with sincerity and altruism in another, as the next letter which Ridley wrote, to a friend called Robert Wightman, bears out:

> I fear the remains of your Danish money is a very unequal fund for a Water Colliery, for your whole fund may be drowned in one year - I know it from fatal experience, so your last condition will be worse than your first, your malt appeared to me a more safe and rational footing, tho' not so grand [2]

Between the extremes - on the one hand where personal animosity between entrepreneurs overrode desires for mutual profit and stood in the way of industrial progress, on the other where feelings of kinship or friendship promoted development - a median process of negotiation presumably pursued more rational lines.

In a setting of unbridled competition with a limited market it is clear that the few collieries which were geographically most favoured (in

1. NRO, Ridley Coll., ZRI/35/12
2. Ibid.

terms of quality of coal, ease of winning, transport costs and labour supply) would have been able to undercut the price of the coal produced by the less favoured collieries and exclude them from the market. Coal would have then been produced only by the most favoured location, subject to its ability to satisfy the whole of the market. Such a situation never really emerged. It was perhaps most nearly approached in the late sixteenth and early seventeenth centuries when the Grand Lease collieries of Gateshead and Whickham dominated production, probably to the detriment of other collieries [1]. With their decline after 1640 the geographical sphere of commercial coalmining widened, encompassing Wearside as well as Tyneside, and was never so localised again.

The self-imposed regulation of the coal trade, which began in 1771 and lasted with little interruption until 1844, was the result of a closer co-operation and greater appreciation of mutual interests among the coal-owners. By 1771, the restrictions preventing non-freemen of Newcastle from shipping coal from the Tyne having been eroded [2], membership of the clique of coal-owners became much less exclusive. The geographical expansion of the industry alone dictated that it should be. An important effect of regulation was that it precluded uncurbed, internecine competition. It restricted the output of the most profitable collieries and allowed the owners of geographically less favoured coal to work it remuneratively;

> an equal portion of sale, according to the powers of each coal-owner,

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1. The depressed state of other collieries, especially those on the north bank of the Tyne, in the first decade of the seventeenth century is probably explained by their inability to compete with Gateshead and Whickham.
2. M. DUNN, op. cit., p 43

> is given to them by the Committee of Management ... if there is no regulation the best coals arrive in the market, and prevent those of the smaller collieries and inferior coals being sold to the same extent [1].

Unfortunately, regulation was always regarded in London as a means of maintaining the price of coal at an artificially high level, a device adopted by monopolistic, northern coal-owners. On the few occasions after 1771 when it was lifted, however, the profitability of collieries appears to have been seriously undermined. In 1829, when William Brandling, Chairman of the Newcastle Coal Committee, reported to a select committee of the House of Commons on the state of the coal trade, he complained that " ... in many cases the coal-owners are losing on the present prices" due to a lack of effective regulation. He was unequivocal in his opinion of the importance of regulation to the industry;

> ... extremely desirable ... It has the tendency to secure a fixed price to the coal-owner ... a means of accomplishing a regular supply to the London Market [2].

Regulation was an important geographical factor. It tended to encourage a spatial dispersal of production. It provided an organisational substratum which, with the geological and technical, formed the basis of the actual pattern on the ground. Thus it may be suggested that, even within a fundamentally capitalistic system, co-operation eventually had an important geographical effect. Undoubtedly the pursuit of profit was still a prime stimulus but profit could be more effectively organised collectively. In 1812 the owners of Cowpen Colliery on the River Blyth

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1. S. C. on the Coal Trade, p.p. 1829, p 10
2. Ibid.

wanted to persuade Sir Matthew White Ridley, the owner of nearby Plessey, to close his colliery and allow the whole of the quantity which had been allotted to the Blyth to be worked from Cowpen. Under such circumstances Cowpen's coal

> ... will be much more advantageously disposed of as the competition which has hitherto existed ... will ... be done entirely away and preclude the necessity of upholding to the shipping the making out of double measure at the London Market and most probably do away the necessity of freighting ships which in most instances is found to be prejudicial to the interest of the coal-owners [1]

This was a situation in which conflict could easily have arisen. But there was no hint of animosity or trouble and an amicable agreement was negotiated with compensation for Ridley and a monopoly of the Blyth vend for Cowpen. It seems likely that the measure of corporate responsibility engendered by the Committee of Coal Owners created a climate which favoured more negotiation and less conflict.

6.9 The viewers

Although the owners controlled the pace of progress in coalmining, and dictated policy for the trade as a whole, they were normally relatively unconcerned with the planning and implementation of coal extraction. Most of them were either ignorant of or uninterested in the complexities of winning and working and, for decision-making at the local level, relied heavily on their colliery viewers. The importance of the viewer as a propogator of new techniques will be discussed later [2], but it is worth discussing here his place in the division of responsibility.

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1. NEIMME, Watson Coll., 9/20
2. See pp 317-8

The viewer emerged fairly early as a separate position in the hierarchical division of colliery labour. In 1611 John Ware was "vewer" of pits at 'Creckborne' in the Manor of Whickham, Durham [1]. In 1631 Guy Smith claimed knowledge of Benwell Colliery by virtue of " ... the survey and viewe of ... Mathew (sic) Hodgson and William Browne" [2]. Five years later Matthew Hodgson, William Hedworth and Chazer Hodgson were " ... appointed ... to view, ride, lyne and survey certaine colepitts in the lopp. of Benwell" [3]. It is therefore safe to assume that the viewer existed as a distinct status at least from the beginning of the period under consideration here. As mining operations became more complex and heavily capitalised the need for technical skill and expertise increased and men who showed exceptional talent became highly prized. Although sometimes overmen had considerable responsibilities for coal-working, and even acted as sub-contractors, it was the resident viewer who was responsible for the winning as a whole. He needed to understand the complexities of drainage, haulage and ventilation. Subject to the ratification of the owners, he made the decisions as to how the colliery should progress. On 20 October, 1741, Richard Ridley wrote to Dr George Sayer

> ... As to our matter of business I now rightly apprehend how the case stands & sd. be very glad to see ye colliery set heartily to work, in order thereto I have employed my skilful men to view & give me ye exact state of ye affair, as far as they can be able to judge, & for ye better information shall set a person to bore immediately, at present they very much discourage me from ye coal being so very bad in Spearman's Freehold wch. adjoins [4].

1. PRO, E 178/5037
2. PRO, E 178/5996
3. PRO, E 134/12 Car 1/East 25
4. NRO, Ridley Coll., ZRI/35/12

Ridley was an entrepreneur very much in control of his own affairs but it was his "skilful men" who had to contend with the realities of coalmining.

The viewers emerged as a class apart from the ordinary pitmen and were often appraised with antipathy by them. They were in fact the ancestors of the modern mining engineer though not until the nineteenth century did they begin to style themselves such. Since they often had to communicate with absentee owners they needed to be literate and articulate. As intermediaries between rather anonymous employers and the clannish pitmen, viewers were often in the rather unenviable position of trying to reconcile conflicting interests. They therefore needed to be tactful managers. The resident viewer's responsibilities could be quite varied. In 1758, for instance, John Watson, then viewer of Hartley Colliery, wrote to his employer claiming expenses

> ... for journeys to Sunderland to view and treat for limestone quarries ... for cash paid for advertising Ford Colliery ... for a survey and plan of the harbour ... for several journeys to Dissington to inspect and set out the borings ... for expenses at Sunderland delivering the sloop ... for a survey and fair plan of the new and old winnings [1].

But such tasks were outside Watson's normal routine;

> the greatest part of the time spent ... was in examining and casting up every article in the Pitts, Engine, Watercharge and Sinking bills and with the same strict examination of the notes charged therein And the extracts of the charges made under the heads of Shiftwork, Oil, Candles, Drifts, Headways and sundry other sorts of underground expence.

1. NRO, Delaval Coll., 2/DE/6/1

Thus in the early phases of industrialisation, before better organisation had more acutely refined the division of responsibility in industrial management, it was necessary for the viewer to be involved in nearly all affairs appertaining to the colliery.

As the level of capital investment in mining enterprises rose, so the burden of responsibility borne by the resident viewer increased. In order to minimise the possibility of personal misjudgement teams of viewers were usually involved in major decisions. In 1756 John Watson wrote to John Hussey Delaval, his employer;

> I was a good deal surprised to find a new Engine Pit booke and preparation making for a new winning of above 60 fathoms deep without any person being consulted, for in a winning of such consequences and expense ... it is the custom of almost every viewer to desire his master to give him leave to call some of his bretheren who he believes to be able judges of such matters to give him their opinions, and assist him in fixing upon not only the cheapest manner of winning but also the place and situation [1].

Experience in mining matters was of absolute importance where progress was, to some extent, a case of avoiding the mistakes of the past. Viewers were therefore required to serve some sort of apprenticeship. John Watson, for example, served his apprenticeship with W N Newton of Burnhopefield, a respected viewer in the first half of the eighteenth century [2]. More often than not the essential skills were passed from father to son and many of the viewers, who were so largely responsible for the development of the Great Northern Coalfield, were derived from

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1. NRO, Delaval Coll., 2/DE/6/1
2. NEIMME, Watson Coll., 8/4, p 1

a few families. The same surnames - Barnes, Brown, Buddle, Claughton, Dalglish, Smith, Watson - recur time and again. It is more than likely that the William Browne who viewed Benwell Colliery in 1631 was an ancestor of the prolific engine-builder of the eighteenth century. In 1842, after his appointment as viewer of Cowpen Colliery, William Watson, the son of John Watson, then deceased, wrote to his new employer;

> I feel proud to find that I shall be able to attend to your request and serve one who was so highly esteemed by my late father. In compliance to your wishes I shall studiously attend to your interest at Cowpen, by so doing, I trust by God's assistance, to gain a share of that confidence which you placed in him who is no more [1]

Astonishingly in Richard Welford's register of 'Men of Mark 'twixt Tyne and Tweed' only one viewer, John Buddle, senior, merits a place and is described as 'The First Mining Engineer', surely an exaggeration. He was the son of a schoolmaster;

> His colliery friends, most of whom worked largely 'by rule of thumb', found him a great assistance in making their calculations ... living among men whose chief pursuits were the winning and working of coal, the elder Buddle became intimately acquainted with the business ... he obtained a knowledge of colliery operations which was afterwards instrumental in raising him from the humble position of village dominie to the more exalted position of colliery manager [2]

Yet in the eighteenth century the viewer's position was hardly exalted. In 1756 John Watson was offered a salary of £50 per year to become the

1. NEIMME, Watson Coll., 9/22
2. R. WELFORD, Men of Mark 'Twixt Tyne and Tweed (1895), vol I, p 425

resident viewer at Chirton. Those viewers who did become wealthy did so by entrepreneurship, usually by becoming the consultant member of a coal-owning partnership. There is considerable evidence that some - Richard Peck, William Brown and John Watson - accumulated considerable fortunes from small beginnings. When John Buddle, junior, died in 1843 he reputedly bequeathed £150,000 [1].

It is both surprising and perturbing that men of the stature of William Brown and John Watson should have passed into obscurity so easily. In some respects Brown's achievement seems no less substantial than George Stephenson's, yet the one stands like a historical colossus while the other lies buried beneath layers of time. Matthias Dunn, nineteenth century viewer and author, began collecting the material for a book, provisionally entitled 'A History of the Viewers'. It was never finished. The manuscript is in the mining institute in Newcastle.

6.10 The pattern of ownership as a factor of location

The individual behaviour of coal-owners was normally of only local importance to the location of coalmining, while the behaviour of viewers was almost mechanistic, a response to perceived geographical, geological and technical conditions. But two factors related to ownership were of greater geographical moment. Both are derived from the simple fact that the pattern of surface ownership which had evolved over the centuries bore no relationship to the geological realities underground upon which coal extraction mainly depended.

Firstly cost of transportation to navigable water was of prime importance in determining the viability of any colliery. Although this cost

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1. F. S. HEWITT, The Papers of John Buddle, Colliery Viewer, in the Mining Institute, Newcastle on Tyne; An annotated list and assessment of their value to the economic historian, M.A. thesis, copy in NEIMME.

depended partly on distance and terrain and partly on the transport technology available to overcome these, it was also greatly influenced by wayleave rents which had to be paid in order to traverse intervening estates. Overland haulage costs were therefore related not only to distance but also to the price of wayleave.

Secondly, the area of coal which a colliery had at its disposal was directly related to the surface area and shape of the royalty. This created many problems underground and altogether led to a rather inefficient method of coalfield exploitation. For example, barriers containing many thousands of tons of coal had to be left intact along the boundaries separating two collieries, so that the drainage, ventilation and working of each was, as far as possible, independent and discrete. In areas where royalties were small and boundaries were tortuous vast quantities of good quality coal were thus rendered unworkable. Because royalties were all shapes and sizes it was difficult for viewers to devise any standard mode of winning and working.

Figure 7 p50 shows the basic pattern of coal royalties in south-east Northumberland. This was derived from the structure of surface estates which, in turn, was largely based upon the ancient manorial subdivision of the county. In the vast majority of cases estate boundaries coincided with royalty boundaries. Benwell is one case at variance with this general rule since the most westerly part of the manor fell within the royalty of East Denton and, in fact, a line of boundary stones was laid out on the surface delimiting this anomalous boundary [1]. In many cases the royalty and the surface estate were owned by the same party. Increasingly, especially with enclosure and the decay of the manor, the surface was sold separately from the mine, and sometimes even subdivided

1. NEIMME, Watson Coll., 9/28; NRO, MBE/IV/5,6

while the old royalty remained intact. Bell's map of 1847 [1] shows that Jesmond, for example, had been divided up into more than thirty separate estates by that time, a process doubtlessly accelerated by its adjacence to the expanding city of Newcastle. Such a divorce of surface and mine created an array of problems, some of which were mentioned above.

But the problem of matching the structure of surface ownership to the realities of underground mineral exploitation had always been vexed. This was especially so when surface ownership was not clearly delimited. For instance, there was occasionally disagreement as to whether land was freehold or copyhold, since wayleave rents were payable on the former but only compensation on the latter. In 1736 Richard Ridley wrote to Archdeacon Sayer, saying that as

> ... The first step toward an agreement ... the boundary of freehold and copyhold lands ought to be fixt; at present he (Mr Spear) claims as freehold what your brother and others deems as copyhold.
>
> A man of undoubted reputation who has lived 65 years on the spot ... (claims) there is no freehold grounds between the copyhold grounds and Tanfield Moor and consequently no wayleave rent to be paid [2].

In the seventeenth and eighteenth centuries the rural landscape in Northumberland was being transformed by enclosure and the other components of the so-called Agricultural Revolution [3]. It was difficult enough for compensation and wayleave rents to be apportioned fairly under the

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1. J. T. W. BELL, Plan of part of the Newcastle Coal District in the County of Northumberland (1847).
2. NRO, Ridley Coll., ZRI/35/12
3. R. A. BUTLIN, An historical geography of the rural landscape of Northumberland, University of Liverpool M.A. thesis, 1963

ancient manorial subdivisions, especially where, as in Benwell, a farmer's strips lay

> ... soe promiscuously intermingled with his freehold and coppiehold that the same could not be plainlie distinguished nor made knowne [1].

But, in addition, a process of piecemeal enclosure was apparent in many Tyneside manors during the seventeenth century and this was apt to confuse the uncertain structure of ownership even further. In 1651 a document referring to Jesmond two decades earlier indicates that " ... Riggs have been exchanged and each person's laid more together" [2]. In Benwell a survey of the fields north of Hadrian's Wall indicates

> All ye north moore above ye wall is two parts kingland and one parte freehold, and soe likewise all ye west moore, but it is not knowne how it is divided and also it is questionable whether parte of ye collery therein belongeth to ye freehold or not [3].

A part of the same manor was also glebe belonging to the Vicar of Newcastle. By 1719, however, Robert Shafto states that " Benwell is so much divided and changed ... that no-body knows where to find the vickers land" [4]. Where such confusion occurred it is possible that the development of coalmining was inhibited to a greater extent than it would have been if the rural landscape had been stable. On the other hand it may be suggested that there was a relationship between coalmining and enclosure, that enclosure represented a rationalisation of land structure which

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1. PRO, E 178/5567
2. NRO, Ridley Coll., ZRI/35/22, p 133
3. NRO, MBE/III/1
4. Ibid.

would benefit both agriculture and extractive industry, and that coalmining disrupted the old manorial system to such an extent that it paved the way for enclosure. It is difficult to find really tangible evidence for this argument but the circumstantial evidence - that coal-mining and enclosure occurred almost simultaneously in some manors - is strong [1].

Since the limits of underground working had to be superimposed from boundaries on the surface of the earth, it is not surprising that there were numerous cases of subterranean trespass. It was the viewer's responsibility periodically to 'line' the workings of a pit, that is to measure their extent from the bottom of the shaft [2]. Where workings were extensive and headways tortuous, however, calculations were difficult, time-consuming and liable to error. Moreover, in the case of trespass, there was the serious question of compensation to be considered. Thousands of tonnes of coal may have been worked illicitly, in effect stolen. In 1749 John Watson discovered a trespass at Netherton Colliery, north of the River Blyth;

> I went down and lined the workings to the N.W. next the Earl of Carlisle's boundary and found he had gone out of his liberty in three or four places [3].

In 1732 Amos and John Barnes

> ... found by lineing the boards that several of the workings of

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1. This is certainly so in the case of Benwell. See PRO, MPA/23, a map of Benwell in 1708, which shows an advanced state of enclosure in contrast to Figure 12.
2. There are many 'lining books' in NEIMME. See shelves 45, 46
3. NEIMME, Watson Coll., 8/4, p 27

> Bucksnook Colliery is wrought into Eweshead Colliery and upon a moderate computation will amount to 166 leading tens [1].

Here perhaps eight thousand tonnes of coal had been illegally taken. Such errors were expensive to the colliery operators. Compensation had to be assessed and paid, labour had been wasted. The penalties visited upon those responsible could be severe. At Jesmond in 1741 Richard Peck and Amos Barnes

> ... viewed the workings of the said Margaret Pit and lined from the ... shaft to the face of the North Headways where we found four persons viz. Gawen Young, Thomas Reavley, Edward Young and George Humble working 21 yards within a close called Moody's House Close ... orders were given ... to discharge the same persons for working any in that liberty [2].

On the other hand it was possible to conceal such trespass for how was a land-owner to know whether coal beneath his estate was being worked from an adjacent colliery or not?

> Having this day lined the workings of a pit in Plessey Colliery called the Oat Pit adjoining Mr John Lawson's estate ... finds that they have wrought out of the said Mr John Lawson's liberty the quantity of two tens, sixteen waggons, twelve bolls of coal ... and has drawn the same to bank at the said Oat Pit, and I further lined until I came to the Quarry Pit's Workings, but could not get near the boundary of the said Mr John Lawson's estate by reason that they had wrought away the walls and brought a thrust in that part of the workings in order that there might no discovery be made of what trespass they had done by the said workings [3].

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1. NEIMME, T. E. Forster Coll., 49/4, p 2
2. Ibid., p 66
3. Ibid. pp 81-3

In practice, such instances of deliberately illicit working were not common since of necessity it involved the complicity of viewers who would thereby put their reputations at risk.

6.11 Outstrokes and wayleaves

If the Great Northern Coalfield had been exploited with no reference to the pattern of coal royalties, in a milieu where winning and working were constrained only by geological and technical conditions, there can be no doubt that the impact of mining would have been substantially different. In such an ideal world much larger tracts of coal could have been won by large-scale pumping and draining operations, and manpower and machinery could have been more effectively deployed [1]. As it was, the viewer, planning the winning of a new colliery could look only as far as the boundary of his royalty. The pits were sunk, the waggonways laid and the engines sited with reference to that boundary [2]. From a mining viewpoint it would have made much more sense to have used fault lines or volcanic intrusions for the limits of a winning. A memorandum of 1817 concerning Cowpen Colliery shows that by then there was at least some awareness of the wastefulness of leaving barriers of coal along royalty boundaries:

> We recommend that instead of leaving the barriers of separation against the respective boundaries of each separate royalty, it will tend to the mutual advantage of all parties to leave such boundaries against certain dykes met with underground [3].

Also, it frequently occurred that small areas of coal within one

1. In the nineteenth century the Tyne Basin Drainage Scheme did centralise pumping operations at Friar's Goose.
2. See Figures 26, 33, 34, 35
3. NEIMME, Buddle Coll., vol 6, pp 183-5

royalty could be more conveniently worked from an adjacent royalty because they were separated from the main winning by a tectonic disturbance and were too small in themselves to justify a separate winning. These were usually the subject of outstroke leases. For example there was such an agreement at Willington in 1813 [1];

> Calculation of the quantity of coal cut off in the south-east angle of Willington Colliery by a dip trouble to the south of 5 fathoms which being proposed to be let to the owners of Temple Main and Bewick and Craster's Wallsend in the following proportions, viz.

	Acres	Roods	Perches
Bewick and Craster's Wallsend	7	1	30
Temple Main	3	1	0
	10	2	30

Such arrangements served to offset the geologically arbitrary nature of mining boundaries. The greatly increased scale of colliery operations at the end of the eighteenth century meant that quite large 'nooks' of coal, which previously might have merited winning as a separate colliery, could be worked by outstroke. Such appendages, of course, could be extremely useful in supplementing the capacity and longevity of a colliery [2]. Figure 25 shows some outstrokes in the Wallsend Basin in the early nineteenth century.

The vexed question of wayleave had affected the progress of the coal industry since its early beginnings. Instances of dispute arising out of wayleave rights have already been cited. One of the chief factors determining colliery viability was access, measured in terms of cost, to

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1. NEIMME, Watson Coll., 13/111
2. See Figure 36.

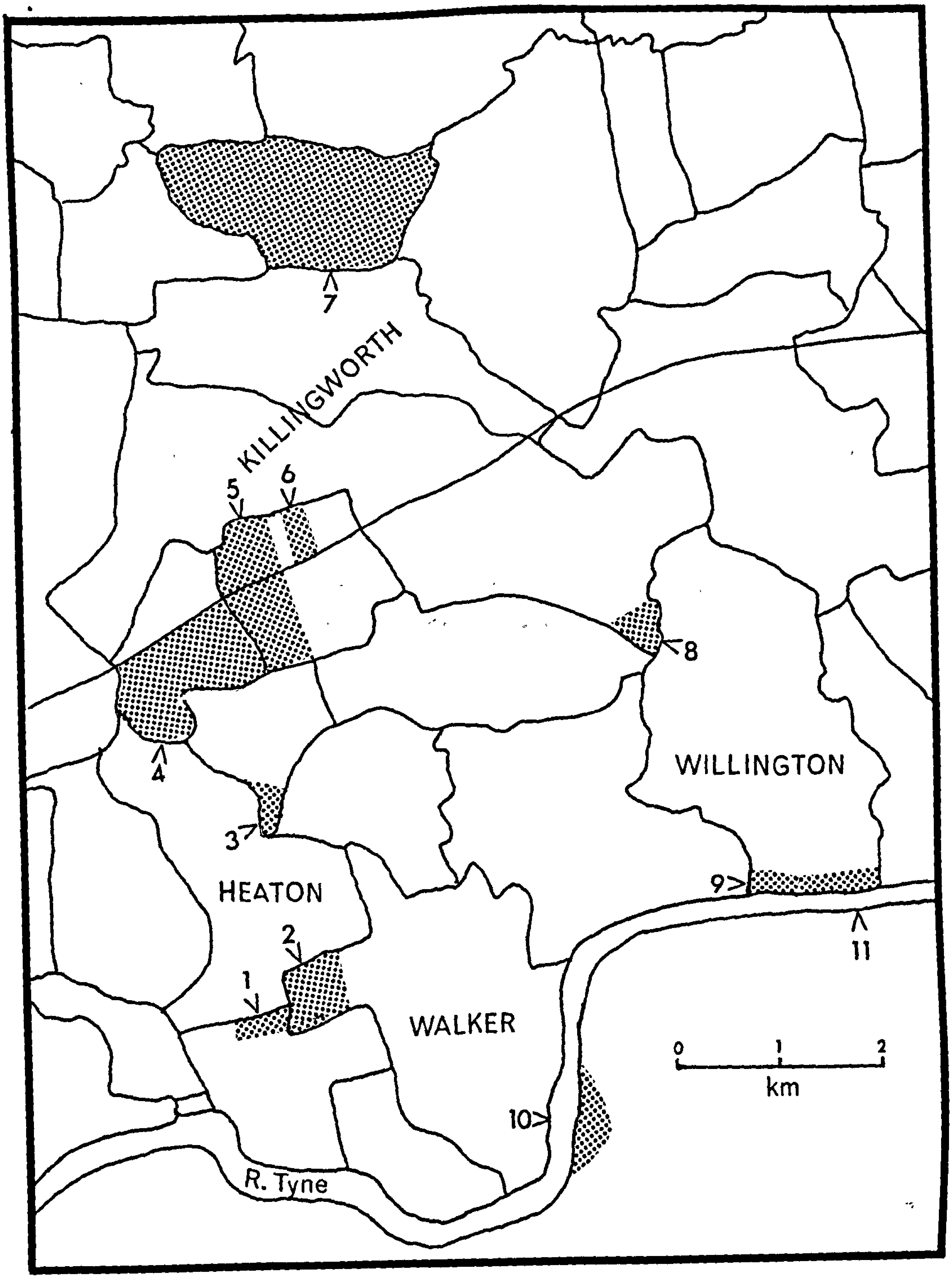

Figure 25 : Outstrokes in the Wallsend Basin (key overleaf)

Key to Figure 25 : Outstrokes in the Wallsend Basin

1. From Heaton into Sir John Lawson's Byker royalty
2. From Heaton into Corporation of Newcastle's Walker royalty
3. From Heaton into C.W. Bigge's Little Benton royalty
4. From Heaton into the Earl of Carlisle's Longbenton royalty and from Longbenton into a royalty owned by Baliol College, Oxford
5. From Killingworth into a royalty owned by Baliol College
6. From Killingworth into Longbenton Glebe
7. Burradon estate let to Killingworth Colliery by outstroke lease
8. From Willington, 41 acres of coal south of a fault in the Earl of Carlisle's Killingworth royalty
9. Part of a royalty owned by the Corporation of Newcastle, let to Willington Colliery and worked by outstroke from Wallsend
10. From the Jane Pit, Walker, part of South Hebburn royalty
11. Part of the Corporation of Newcastle's royalty, sub-let by Willington Colliery to Temple Main Colliery and worked by outstroke under the river Tyne

navigable water; in south-east Northumberland this meant to the Tyne and, for a few collieries, to the Blyth or to shipping facilities on the Northumberland coast. The cost of access was partly determined by technology, for it was the incentive to reduce haulage costs which promoted enormous strides in railway development here between 1650 and 1820, and partly, of course, by distance. But another determinant was the structure of landownership since estate owners invariably expected rents in exchange for right of way across their lands. This placed collieries which were far removed from navigable water at an additional disadvantage compared with Tyne-bank pits. Not only did they have to build and maintain waggonways and rolling stock, keep waggon horses and employ waggonmen but they had to pay hefty rents to each landlord who permitted their coal to cross his estate. In 1696 the Hostmen of Newcastle sent a petition to Parliament which

> ... sheweth that of late years the colyeries adjacent to the river Tyne are so wrought out that the coal owners have been forced to advance their workes several miles further from the river Tyne into the country to digg for fresh supplies for the service of the City of London and diverse parts of the kingdom, by means whereof they are under necessity of carrying their coales through other mens' grounds and alsoe making of water-courses to win and drain the coale mines through other mens' grounds who for the damages occasioned by granting such liberty exact such extravagant rates from ye petitioners for wayleave and staith room as is no small prejudice and discouragement to the trade and will tend to the raising of the rates and prices of coales in the kingdom [1].

It is not surprising therefore that in a period of excess capacity in the industry, perhaps leading to reduced prices for coal, it would

1. M. ARCHER, op.cit., pp 162-3

almost certainly be 'the distant collieries' which suffered most. Table 16 is a list of the rents paid by the lessees of Kenton and Coxlodge Colliery in 1804. Out of an outlay of £1870 per annum £770 were disbursed to gain right of way through other estates. In addition most landowners demanded a tentale payment for leadings in excess of the stipulated quantity. The choice of a route from pithead to staith was therefore a key decision. There were often alternatives which had to be carefully weighed. Table 17 shows a comparison of two alternatives which were considered when Seghill Colliery was being opened. Routes were important and the structure of landownership influenced not only the choice of alternatives but even the actual delineation of lines. Figure 26 , showing the relationship of lines to estate boundaries, suggests strongly that the orientation of waggonways was affected by estate boundaries. This is most noticeable where the long waggonways from Cramlington, Seghill and Brunton funnel through Flatworth and Shiremoor, and in the way the line from Longbenton Moor (Bells' and Brown's Wallsend Colliery) avoids, by turning through almost ninety degrees, passing through Wallsend Royalty.

Once a waggonway link had been established, however, it could become a locational factor in itself. Its existence could be a tangible advantage weighing in favour of the opening of a colliery. When the Benton Pit was opened at Heaton Colliery in 1834, for example, it was commented that

> ... The pit is situated contiguous to Coxlodge wagonway which presents a very favourable route for conveying the coals to the staith [1]

And when John Watson was negotiating wayleave for Seghill Colliery

1. NEIMME, Watson Coll., 10/44

TABLE 16 : Kenton and Coxlodge Colliery

Rents payable in 1804

Mr Wilson	for	Kenton Colliery	£500
R. Riddell, esq.	"	Coxlodge Colliery	£500
Mr Wilson	"	Coxlodge outstroke	£100
M. Montague esq.	"	watercourse and wayleave	£100
Mr Stephenson	"	wayleave	£100
R. Warwick	"	"	£100
I.B. Coulson	"	"	£90
Duke of Portland	"	"	£80
Mr Bulman	"	"	£60
Mr Brandling	"	"	£60
Messrs. Bewick & Craster	"	"	£60
Mr Wilkinson	"	"	£60
Sir John Lawson	"	"	£60
			£1,870

Source: NEIMME, Watson Coll., 9/13

TABLE 17 : Alternative wayleave from Seghill Colliery

	Distance (yards)	Certain Rent (£'s)	Tentale Rent (s/d)
To Willington Quay:			
Sir Francis Blake/Seghill	343		
R.W. Grey/Backworth	4536	400	5/-
A. Liddell/Shiremoor	506	25	
F. Stanhope/Willington	1491	200	2/-
Sir Ralph Milbanke/Willington	1487	150	2/-
Bewick and Craster/Willington	880	150	1/6
Corp. of Newcastle/Willington	220	100	1/6
	9463	1025	
To Wallsend:			
Sir Francis Blake/Seghill	220		
W. Ogle/Burradon	1152	200	2/6
H. Entrick Reay/Killingworth	1394	300	3/-
N. Punshon/Killingworth	198	50	
T. Bonner/Killingworth	787	100	
H. Entrick Reay/Killingworth	567	100	
Bewick and Craster/Benton	1874	200	3/-
Dean and Chapter of D./Wallsend	2200	250	3/-
	8392	1100	

Source: NEIMME, Watson Coll., 13/95

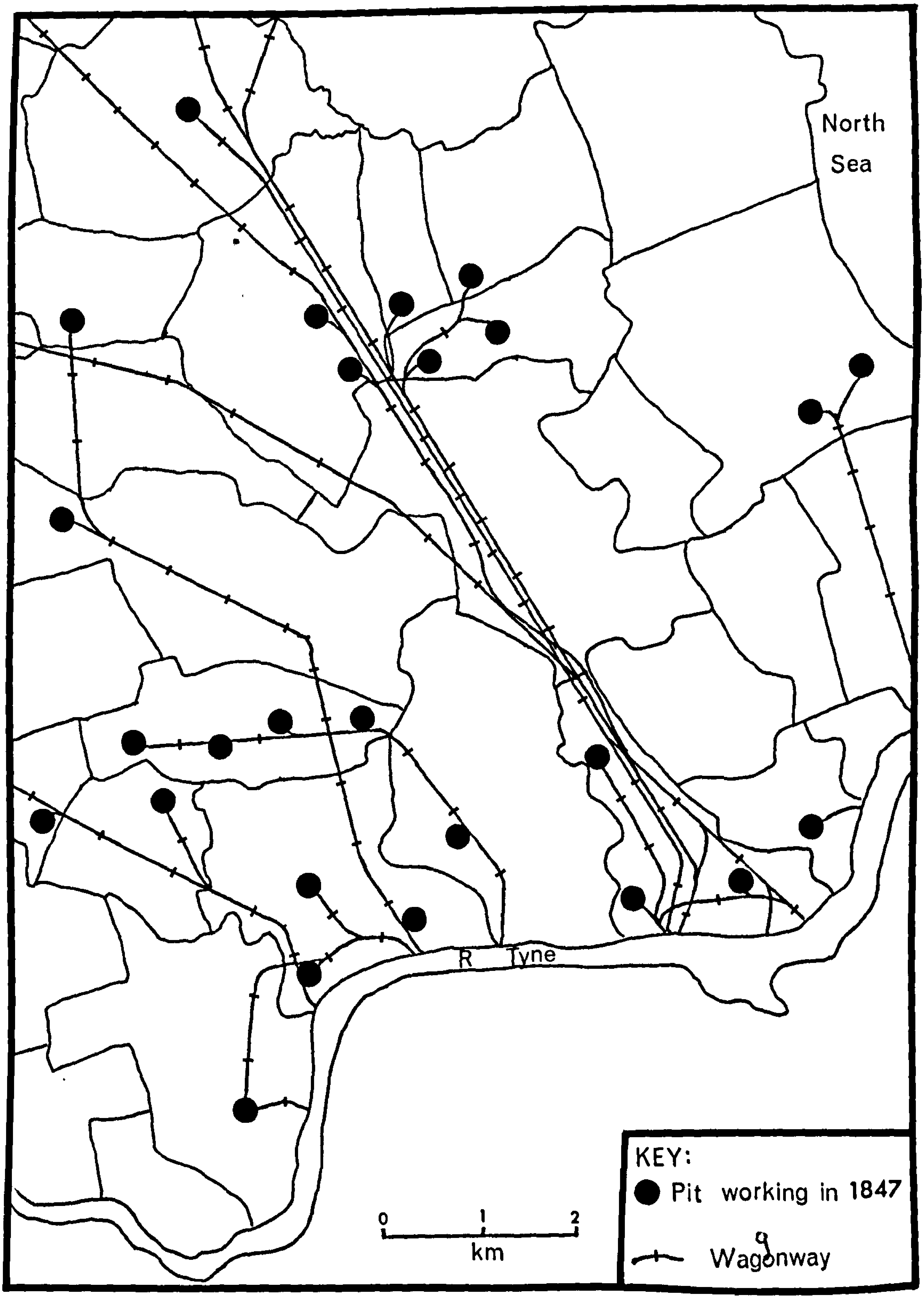

Figure 26 :—Waggonway routes and estate boundaries

1847 (Bell's map of Great Northern Coalfield) in 1824 he attempted to obtain from the owners of Backworth permission to use part of their existing line for transporting Seghill coal [1]. Some lines therefore became established routes and did not necessarily become disused when the original parent colliery closed (the line of the Cramlington waggonway was used well into the second half of the twentieth century). Some were even later utilised for passenger railways. In fact, old colliery railways are being incorporated into the Tyneside rapid transit system which is being built at the present time.

1. See p 182

CHAPTER SEVEN

CHANGING TECHNOLOGY

> As it is justly remarked that necessity is the mother of invention, so does it necessarily follow that colliery engineering may be said to have arrived at a state of greater perfection in this district than in any other part of the world. In the first place the quantities raised have exceeded those of all other parts; and the depths of the pits, the quantity of water, and above all, the great and general discharges of inflammable air have necessarily demanded the most effective practical science.
>
> Matthias Dunn, 1844

The development of the Great Northern Coalfield occurred in symbiosis with the progress of mining technology. It is now well understood that technical innovation was part and parcel of the British industrial revolution. Moreover, as has already been pointed out, new technology was even more crucial to the development of mining because in extractive industry there can be no steady state of equilibrium. Since coal resources are non-replaceable mining proceeds from the most accessible to the least accessible underground location. The technological challenge is therefore relentless. If it is not too macabre a double entendre it would be true to say that for the miner it was a case of innovate or die!

It was the adoption of new technology which transformed the mining process from the superficial 'digging' along the outcrops, using basic tools and manual labour, which supplied the demand for coal in the fourteenth and fifteenth centuries to the heavily capitalised winning of the centre of the Wallsend Basin at depths of over 100 fathoms (183 metres) by the turn of the nineteenth century. Before 1600 there must have been some technical progress considering that the industry was then some centuries old. It seems likely, however, that because there was so much shallow outcrop coal available and demand was limited the technological challenge was less great. It required a surge in demand and the exhaustion of some key deposits before the dangers of dearth were fully perceived. This occurred by the middle of the seventeenth century.

As early as 1610, however, Sir George Selby, a Newcastle Hostman and member of Parliament, informed the government that "... the coal mines at Newcastle would not hold out the term of their lease of 21 years" [1]. A century later the 'Compleat Collier' says that

> ... If it could be made apparent that, as we have noised abroad there is this and that invention found out to draw out all great old wastes, or drowned collieries, of what depth soever, I dare assure such artists may have such encouragement as would keep them their coach and six: for we cannot do it by our engines, and there are several good collieries which lie unwrought and drowned for want of such noble engines and methods as are talked of or pretended to [2].

Paradoxically, however, the Tyneside collieries had to be closed in 1665 because of a huge surplus. In general, given the existing technological base, productive capacity was far in excess of demand. T. J. Taylor commented interestingly on the reasons for this:

> The tendency to overproduction in the coal trade has been felt in all its epochs, and is as much the character of the trade at the present day as it was in the reign of James I. The reason is not of difficult discovery. Coal resembles a stock of material

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1. T. J. TAYLOR, op. cit., p 39
2. J. C., The Compleat Collier, (1708), p 29

> laid up in store, and always ready for use without any previous preparation, except that of merely severing and carrying it away. In this respect it differs essentially from those articles of commerce which require to be perfected by much labour, or which, being the growth of twelve months' culture, are precluded from increasing too fast on the hands of the owner; and this inherent difference is the true cause of the necessity which has been, and will be, felt, for an artificial adjustment of supply and demand in the coal trade [1].

In fact, incapacity of the collieries was never a reason for shortage at the London market (although shortages during wartime did occur with the dislocation of coastal shipping). But this is not necessarily a symptom of a continually successful technological response. Indeed there are many examples of the failure of technology to cope with problems underground. Such failure, however, was normally of only local significance and simply meant that production was stepped up or begun elsewhere. For instance, at the end of the seventeenth century when the Tyne-bank collieries, in their attempts to win deeper coal, were thwarted by drainage problems it was the signal for an areal extension of the industry to obtain shallower deposits at greater distance from the river and not a direct threat to the industry as a whole. It would be true to say therefore that the technological challenge was present in relative, rather than absolute, terms. There would not be a complete failure of supply; instead the price of coal would rise because it had to be brought over greater distances. The advantages of new technology were measured in terms of cost. Adoption was usually seen as a means of improving profit margins by reducing working costs. Great technological advances, like steam pumping, or the railed way, or the use of boring techniques, were not perceived as such at the time of their

1. T. J. TAYLOR, op. cit., p 69

introduction. It took years before their superiority over existing technology was finally proven and recognised. Adoption was gradual and complex, almost a process of assimilation.

7.1 The technological base of the early seventeenth century

By 1600 the technological basis of coal mining had achieved some refinement. In the Crown Survey of 1611 there are twenty-two pits, whose depths are mentioned, in seventeen collieries [1]. The average depth of these is 12.7 fathoms (23 metres). A few pits, however, had penetrated much deeper than this. At Benwell one was 25 fathoms deep and another, the deepest, had reached 32 fathoms. Three pits at Gateshead were over 18 fathoms deep. Such winnings must imply a degree of technological sophistication. Clearly techniques of sinking, timbering, ventilation, drainage, underground haulage and drawing coal must have been reasonably effective. George Watson, an overman at Denton in 1611, stated that there was "no wholle myne" in his pit and that workings were from "pillars and styntens". This proves that the 'bord and pillar' method of working was used. It was not superseded until the mid-nineteenth century. At Benwell it was suggested that two pits in the Higher Strip would last for twenty years "... so long as good care be had to keep open the passages of water and air and upholding" [2]. According to the 'banckeman' of a pit eleven fathoms deep at Tudhoe colliery, in Durham,

> ... The water is forced or pumped from her five yardes hie ... The profitte which can be made of that pitte yf she be well proped with tymber is worthe twenty poundes per annum all charges deducted [3].

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1. PRO, E 178/5037
2. Ibid.
3. Ibid.

Since the pit was 11 fathoms (30 metres) deep and the water was raised only 4.5 metres this must have been an example of 'pit and adit' working. The use of delivery or offtake drifts avoided the necessity of pumping to the surface and economised drainage operations enormously [1]. Indeed, as was pointed out earlier, it was the peculiar suitability of the Tyne Gorge and the lower Ouseburn and Derwent valleys to 'pit and adit' techniques which was a prime cause of the initial rise of the coal industry around Newcastle. Vast quantities of coal in Jesmond, Heaton, Benwell, Elswick and Denton were both above the level of free drainage and virtually a few hundred yards from navigable water. At this time, when muscle-power was the only alternative source of energy, gravity-assisted drainage was of the greatest importance in winning coalmines.

Indeed, apart from this, all of the techniques for working coal in 1600 relied on human labour. At the coal-face the hewer 'kirved' the coal from the seam, taking care to produce as much 'round' and as little dross as possible. It was shovelled into corves and hauled on sledges to the bottom of the shaft by a team of two men, a 'barrowman' in harness pulling in front and a 'putter' pushing behind. At the foot of the shaft the 'onsetter' hitched the corve to the end of a three-inch thick rope and it was raised under the supervision of a 'bankman' by means of a windlass or 'jack-roll'. As far as surface haulage from pit-head to staith was concerned horses and oxen hauling carts and wains were used and gravity was probably always of some assistance, although much more so with the advent of waggonways. If the technology of the early seventeenth century was simple it was also relatively effective in the context of shallow, uncomplicated coal workings.

Two problems recurred repeatedly despite all this however; drainage

1. See Figure 37

and roof collapse. At Hartley, in 1611, "... the myne is wasted and drowned and noe hope of recovery". Although the inference here is that it would be impossible to drain the mine, elsewhere the limits were financial. At Preston

> ... every pitte would be worth twentie markes per ann. yf the water could be drawen but ... noe reasonable charge can drawe the water whereby profitt may be made.

At Cowpen the conclusion was that

> ... if the water can be nonne, which as yet yt is not, than there will be myne for two pitts to be wrought and to continue for forty years ... what charge will mynne the said myne he knoweth not.

At Amble, on the coast north of Blyth, where there were pits in association with salt pans, "... there is great quantitye of myne to endure for many yeares yf the water could be drawwen or wonne". But there was an additional problem there "... the roofe is badd and falls of ytselfe". And at Tynemouth "... Every pitte will be worth de clavo twenty poundes if the baddnes of the roofe be noe hindrance" [1].

Clearly, the simple hand-worked, rag-and-chain pumps could not be expected to cope with substantial 'feeders' of water, nor to raise large quantities more than a few metres. The problem of roof collapse however, was not entirely due to inadequate technology. It was also simply a result of the shallowness of the workings. Near to the surface, the strata having been more affected by percolating water and other geomorphic

1. PRO, E 178/5037

influences, the roof of a mine tended to be less solid. More than a century later, in 1735, the existence and, indeed, persistence of this problem is elucidated in a view of Eweshurst Colliery, in Durham. A dilemma had arisen as to the continued working of the Whin Pit there. Two reports were elicited from two pairs of consultant viewers

> ... wherein Mr William Dalglish and Mr Rawlings gives their judgement and opinion that the whole mine of coal on the north side of the said pitt is not merchantable, but they agreeing with our (i.e. Amos Barnes and Richard Peck) opinion at the same time that the coal on the south side joining the same to the east and west may be wrought in the whole and walls (and) is merchantable ... it is our opinion that the coal they say is not merchantable seems to be as good coal as that which they admit of [1].

Clearly there was a divergence of opinion. But Dalglish and Rawlings were quite adamant;

> we found ... that they had wrought in the north side of the shaft of the said pitt till they are but about 48 yards of the outburst (i.e. the surface outcrop) and the coal is very tender and the roof very bad insomuch as it is very dangerous for men to work under, but supposing it was possible to get men to venture a little further we are fully satisfied and give our opinion that they cannot be wrought merchantable there [2].

Figure 27 shows the diagram and explanation appended to their view by Rawlings and Dalglish. It is clear that problems of mine security tended to increase and the quality of coal decrease as workings approached the surface 'outburst'. The effect on coal quality explains why at Elswick

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1. NEIMME, T.E. Forster Coll., 49/4, p 8
2. Ibid.

" A. the top of the shaft; B. the bottom of the shaft; BC. the coal from the shaft to the outburst; AC. the ground or surface from the shaft to the outburst.

From B to E they have wrought after the usual manner of working that seam (that is) 8 yards to each winning four taken away and four left the walls, from E to D they have only taken between five and six yards to a winning, some more than three taken away and about two left to the walls. Now DC is the coal in dispute and no man of judgement we are sure will make oath that the coal can be wrought merchantable there"

Thomas Rawlings and William Dalglish, 1735

Figure 27 : Eweshurst Colliery, pit and adit working

in 1611 a seam "two yardes and better in thickness", obviously the High Main (since it outcropped in Elswick and no other seam was as thick), produced only "a panne coale" at 7 to 10 fathoms from the surface. In 1738 Thomas Stokoe commented that coal tended to improve in quality as "... they get more into the heart of the country" [1]. The poor consolidation of roof cover was very rarely a problem for the winnings of the later eighteenth and nineteenth centuries.

By 1600, then, a rudimentary technological base had developed and some of the problems which have always bedevilled man's pursuit of minerals had certainly been encountered. How then did the inevitable progress of technology proceed from there? That it was, in the first instance and most obviously, a simple process of challenge-and-response is certain. For the miner the physical problems were all too evident, the need to solve them only too pressing. Man's innate technical ingenuity must have been constantly stimulated. As Matthias Dunn put it, the problems "necessarily demanded the most effective practical science" [2]. The process of innovation must have been almost constant, embracing a myriad of improvements both minor and momentous. At the same time, however, the great advances which revolutionised prospecting, pumping, ventilation or haulage were few and far between. Moreover, the coal-fields were more a melting-pot than a cradle of new ideas. Many of the scientific principles which were the basis of new techniques were discovered elsewhere and imported. Agricola's description of the techniques used in the metal mines of central Europe in the middle of the sixteenth century suggests that few, if any, of the techniques used in Northumberland in the seventeenth century were inventive [3]. The coalfields bred

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1. NEIMME, Buddle Coll., vol 14, pp 350-1
2. M. DUNN, op. cit., p 38
3. G. AGRICOLA, De Re Metallica, libri XII (1556)

innovators rather than inventors, improvers rather than instigators. Their role in the progress of technology should not be diminished by this, however, despite the fact that historians seem to elevate inventors and forget innovators (Thomas Newcomen is a famous name, William Brown is virtually unheard of). It is one thing to invent a method of propulsion using steam power; it is quite another to practically adapt it to drawing water from a coalmine.

During the seventeenth century there were three major technological advances which affected the progress of coalmining in the north of England to varying degrees, namely the introduction of techniques of boring to prospecting, the use of water power for drainage purposes and the advent of waggonways.

7.2 Prospecting

Among the "rare engines" which Huntingdon Beaumont brought with him when he came to the north during the first decade of the seventeenth century were "the art to boore with, iron rodds to try the deepnesse and thicknesse of the coale" and "waggons with one horse to carry down coales from the pits, to the stathes, to the river" [1]. It seems likely that both these techniques originated on the continent, probably in the metal mines of Germany, that they were first tried in England at Wollaton in Nottinghamshire [2] and that the ideas were brought from there to Northumberland by Beaumont. But what happened then? Did the failure of Beaumont's enterprise at Bebside affect the acceptance of the new techniques? Galloway states that in 1618 a payment is recorded in the household books of Naworth Castle for "a set of boring rods bought at

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1. W. GRAY, op. cit., p 86
2. R. S. SMITH, 'Huntingdon Beaumont, Adventurer in Coalmines' Renaissance and Modern Studies, I (1958), pp 115-53

Newcastle". He also claims that in 1639

> ... a series of borings were made by one Thomas Wake in the neighbourhood of Leeds. Borers of this name continued to practice the art long subsequently in the Newcastle district [1].

Mark Archer also mentions a borer called Thomas Wake at work in 1692 [2]. During the eighteenth century there are many references to borings by members of the Wake family in Northumberland. But the Benwell Manorial Records reveal that Thomas Wake was resident in the manor at least as early as 1661 [3]. He was the lessee of a pit in Windyside at that date. By 1671 ~~Moreover~~, he appears to have become a substantial property-owner since ~~by 1671~~ he owned eight houses in Benwell and was listed as one of the fourteen farmers of the manor.

It seems likely that Thomas Wake, possibly a native of Yorkshire and a man of considerable resource, having obtained the skills of a borer moved to that part of the country where he could best put them to use, the Newcastle Coalfield, probably at some time between 1640 and 1660. By that time the existence of the technique had been known in the area for thirty years or more and its usefulness may have been proven. The rarity of his skill probably enabled him to prosper (subsequently many coalmining technologists profited thus) and to become materially comfortable. Such an interpretation is tentative but appears to fit the facts as they stand.

But what was the impact of the new technique on the industry? Again, due to a lack of clear documentation, this is difficult to determine.

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1. R. L. GALLOWAY, History, p 60
2. M. ARCHER, op. cit., p 160
3. NRO, MBE/III/1

At first it was probably inconsiderable. Since mining was already established in recognised localities it was probably difficult for a new method of prospecting to have more than a local significance. It certainly did not precipitate a 'coal rush'. Boring was time-consuming, laborious and costly [1]. Since it required considerable expertise there was probably a shortage of skilled borers. It is remarkable that even by 1800 most of the borings in Northumberland had been carried out by the members of two families - the Wakes and the Rawlings. Moreover, it is doubtful whether at this date boring had achieved the technical effectiveness and sophistication which was attained after years of practice. At first it was probably used as a method for proving ~~of testing for~~ the existence of deposits already suspected in areas near to existing collieries. In fact the prospector would never rely completely on boring for there were other tokens of the presence of coal;

> in grounds of an undulating form, well advanced into systems of secondary stratification, and composed of sandstone and schistus, coal-seams are commonly found; and as they always have, in common with their concomitant strata, their commencement at the surface of the earth, their crop or outburst is often seen in the faces of quarries, in the ditches of fences, and in the beds of brooks, and frequently in thin soils is turned up by the plough; in

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1. Not surprisingly the cost of boring escalated rapidly with depth. At Denton, in 1733, John Rawlings charged five shillings for each of the first ten fathoms and then an additional five shillings per fathom for every subsequent five fathoms. Thus, by the time forty fathoms had been exceeded the cost was £2 per fathom. Since adequate exploration really required a number of bore-holes the whole process could be quite costly. See NEIMME, shelf 18, Richard Peck's View Book. For a precise description of the actual process see G. C. GREENWELL, <u>A Glossary of Terms used in the Coal Trade of Northumberland and Durham</u> (1888), pp 9-11

> these situations the coal is always of a soft sooty substance and of a brownish black colour; and from its being found in the crow or crop of the earth has obtained the name of crow coal. Strata of coal also from their porous nature, frequently become the feeders of springs which cast up small pieces of coal, and are tinged with a dark, ochery substance proceeding from the decompostion of coal or pyrites, by the united action of water and atmospheric air; for pyrites if not mixed with the coal are commonly found in the schistus beds, composing the roof or floor of the coal seams. Sometimes a long line of springs is found in the direction of the outburst of seams on the dip side of hills. These, when they are covered with a blue, oily coloured scum, and afford an astringent water and, like the other, eject particles of coal, whether they merely swamp the ground, or yield a brisk current, are reckoned good indicators of a stratum of coal [1]

Knowledge of the stratigraphical characteristics of coalfields grew empirically. Every pit which was sunk added to the store of data, a store which initially was held in the memories of viewers, borers and overmen and passed on by word of mouth. Later it was recorded in their diaries, accounts and reports. Evidence of the disposition of seams was gained initially by correlation and comparison of adjacent pit shafts. The boring technique lessened the hazard involved in winning since it enabled a preliminary exploration of the strata without the necessity of sinking a pit. It was used for verification rather than discovery. Even so it was by no means infallible as John Watson pointed out to his employer in 1756, citing the example of Chirton Colliery where three boreholes were made

> ... which found the coal in perfection in all three ... yet when they came to sink their engine shaft they could not find the coal

1. NEIMME, Bell Coll., vol I,p 484; from an extract by J. HODGSON in Akenhead's Picture of Newcastle.

> and have spent $1\frac{1}{2}$ years as well as many thousand pounds in seeking for it, tho' they were only seventy yards distant from one of these boreholes [1].

In fact prospecting effectively for coal seems to have remained problematical throughout the seventeenth and eighteenth centuries. In 1792 George Johnson commented interestingly to this effect;

> The business of searching for coal is frequently tedious and complicated and sometimes precarious. Could the common indications of.coal be depended upon attempts to find the article would be both simple and effectual. But the truth is that they amount in the mind of the intelligent observer only to a presumptive argument ...
>
> For my part I am inclined to think that when an unworkable seam of coal has been discovered near the surface of the earth other seams of a workable nature are to be found if duly searched for below. And I impute the exceptions which have been adduced to this remark to have arisen either from the stupidity of the borer or from the excessive economy of the person who defrays the expense thereof. When we recollect that boring is the only effectual mode (except sinking and drifting in certain situations) we have of getting a considerable distance into the Earth not only in quest of coal but other valuable bodies it is very extraordinary indeed to find there are only a few individuals in Great Britain who have any claim to merit in that business. It is therefore not singular if hasty conclusions are drawn in searching for coal when borers who are both extremely illiterate and stupid are in general those who establish facts relative thereto [2].

1. NRO, Delaval Coll., 2/DE/6/1
2. NEIMME, T.E. Forster Coll., 49/7 , pp 7-8

7.3 Surface transport

If his introduction of techniques of boring to the Great Northern Coalfield brought no revolution in prospecting for coal, Beaumont's "waggons with one horse" were certainly a precursor of far-reaching, perhaps revolutionary, change. M.J.T. Lewis has now examined in some depth the initial diffusion of the railed way in Britain [1] so that it is not necessary to explore the wider implications of the subject here. The technological development of surface transport had an important effect on the geography of coalmining, however, and it is therefore worth briefly looking at some aspects with regard to Northumberland.

A tantalising half century elapses between Beaumont's experiments at Bebside in the first decade of the seventeenth century and the 1670s, when there is irrefutable evidence of the employment of waggonways. Roger North's description of them in 1676 is well-known;

> The manner of carriage is by laying rails of timber from the colliery down to the river, exactly straight and parallel; and bulky carts are made with four rowlers, fitting these rails whereby the carriage is so easy that one horse will draw down four or five chaldron of coals and is an immense benefit to the coal merchants [2].

But the impression of widespread adoption given by North's description is misleading. It almost certainly refers to the Ravensworth 'old way' built by the Liddells, probably in 1669 [3].

In evidence presented at a legal case in 1731 it is stated that

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1. M.J.T. LEWIS, op. cit., pp 86-137
2. R. NORTH, op. cit., p 176
3. M.J.T. LEWIS, op. cit., p 120

... Some short time before the said sale to Mr Christian (the date of the sale is 1671) a new method was invented for carrying coles to the river in large machines called waggons ... these sort of ways were only made use of for a small number of collieries in 1671 [1].

Matthias Dunn states that it was not until 1693 that "... Waggons were first used on the River Wear at Allan's Flatts" [2]. And yet there is no evidence that the coal-owners of the Wear distinguished themselves by a reluctance to adopt new techniques.

The question of whether there were any waggonways built between Beaumont's at Bebside before 1610 and the Ravensworth way of 1669 is vexed. Lewis draws attention to the probability of one at Dunston in about 1640. But there is no evidence of an actual line and he derives his conclusions from the use of the word 'waggon' in parish registers, claiming a precise semantic distinction between 'waggon' and 'wain'.

It seems likely, however, that the Ravensworth line was built on some model and a small line at Dunston seems probable. Consequently, it was in this area, on the south bank of the Tyne to the west of Gateshead, that the first successful 'Newcastle Roads' were built. Why should this be so? Firstly, because Ravensworth was one of the collieries most distant from staith at that time. Obviously the collieries which could hope to benefit most from a new method of overland haulage were those which suffered from the longest surface hauls. It was a notable aspect of the adoption process that collieries near to navigable water were reluctant to invest in expensive permanent way. Secondly, the Liddells of Ravesworth were among the most successful of coal-owners and later

1. PRO, C 11/690/12
2. M. DUNN, op. cit., p 19

distinguished themselves by their willingness to back new techniques (the steam engine at Heaton and Stephenson's locomotives at Longbenton, for example). In evidence to the 1738 parliamentary enquiry, when asked when waggonways were first used, John Millet replied rather obliquely, "... Col. Liddell and his family had waggonways". At the same time he said that they were only used "... in collieries that lie distant from the Rivers, those that lie near the river have no occasion for them" [1]. Thirdly, a waggonway linking Ravensworth to Team Staith following the Team Valley would cross fairly flat and gentle terrain. The construction of waggonways required large-scale capital investment much of which was spent on levelling (building bridges and embankments, and excavating cuttings). It would have been possible to lay a fairly cheap waggonway along the Team Valley.

The role of waggonways, in connection with wayleave problems, was discussed at some length in 1738 at the parliamentary enquiry. It was stated that there were 42 miles (67.5 kilometres) of way in existence by then. One of the witnesses, Thomas Stokoe, observed, however, that waggonways "... have been increasing ever since the year 1722" [2]. This again suggests that they were used on only a small scale before that and that their adoption was a very gradual process. By 1738, however, their impact had been considerable;

> many collieries (are) now at work which 20 years ago were not practicable to be brought down to the river ...there is Parson's Tanfield and Davison's Tanfield which people thought impossible to be brought down to the river by the way they now come ... because the expense was so great, they being brought down by waggonway and there being two great bridges built ...

1. NEIMME, Buddle Coll., vol 14, p 320
2. Ibid., p 353-4

> Tanfield Bridge, gentlemen came to see on purpose who say it was the largest they ever saw [1].

Such feats of engineering represented to the owner "... an expense so large that no private person could go through with them". Hence it was only partnerships such as the Grand Alliance which could afford the initial capital outlay.

M.J.T. Lewis has produced a map of the early waggonways around Tyneside with their dates (actual or approximate) of construction [2]. He includes a line at Benwell in 1708 where, almost certainly, none existed. The difficulty and expense of construction meant that, at first, only collieries with long hauls to staith appreciated the advantages of permanent way. Collieries near to the rivers made do with carts and wains well into the eighteenth century. Dunn states that, even in 1725, at Jesmond "... Upwards of 700 wains were employed in leading coals down to the Ouseburn", while at Elswick "... From 600 to 700 carts were employed in leading ... coals down to Scotswood Quay". Twenty years after the building nearby of the Ravensworth line "... Whickham Colliery still used 600 wains to transport coal to Derwent Staiths" [3]. In Richard Peck's View Book there is

> ... An account of the height, breadth and length of Mr Wm Kelly's wayns and carts at Whorlton Moor being the same measure as Mr Denham had at Dunston in 1710.

In the second decade of the eighteenth century Peck reckoned that it

1. NEIMME, Buddle Coll., vol 14, p 353
2. M.J.T. LEWIS, op. cit. pp 112-3
3. M. DUNN, op. cit., p 19

cost 2s 6½d to lay a yard of waggonway (cost of rails and sleepers plus labour) and that the cost of building a waggon to hold 20 bolls was £7 - 1s - 2d. The capacity of a wain at that time was 6½ bolls. The gauge of the Ravensworth waggonway he gives as 3 feet 10 inches [1].

In 1714 Peck also computed the cost of a winning at Throckley Colliery estimating the expense of "making a wayn way and setting gates" as £50. But, as an afterthought, Peck observes "... If you have occation (sic) for a waggonway it will be about 3 miles long and may cost £1,034" [2]. There was thus an enormous difference in initial capital costs. Even in 1726, when appraising the cost of a re-winning of Hartley Colliery, Peck offers alternatives;

> the medium in leading will be about 6d per foth.with waine carrage ... there is very good convenience for laying a waggonway but the charge we have not computed [3].

Thus, half a century after they had first been successfully adopted and perhaps an hundred and twenty years after they had first been introduced, waggonways had not completely superseded wain haulage.

Initially, it was in north-west Durham that the advantages of the new method of transport were most persuasive and it was there that the greatest length of wooden permanent way was built. In Northumberland, however, there were only a few waggonways in use before 1750. The Ninety Fathom Dyke limited the northward spread of coalmining on the north side of the Tyne and so there were only a few collieries with substantial hauls to staith by then. Significantly the first collieries in the

1. NEIMME, shelf 18, Richard Peck's View Book, p 17
2. Ibid., pp 21-6
3. Ibid., p 6

county to adopt the new technique did not deliver their coal to the Tyne. These were Whitley Colliery which shipped from Cullercoats and Plessey Colliery which shipped from Blyth. Of these the Whitley waggonway was probably the first, for it was written into the lease for the land used for the harbour installations at Cullercoats that a waggonway fifteen yards in breadth should connect the workings with the shipping facilities [1]. Shipments of coal from Cullercoats began in 1679 [2] so that if the waggonway dates from then it was an early example indeed. In 1704 the lessees of Whitley Colliery agreed to pay Richard Young, a Newcastle carpenter 8s 6d for every tenn (of twenty-three waggonloads) of coal led to the staith for the maintenance of the main waggonway, its branches, the staiths and trunks, and thirty-nine waggons. The Plessey waggonway, which was over five miles long, was built in the early years of the eighteenth century and completed about 1704. It linked shallow pits at Hartford, Cramlington and Plessey to staiths at the mouth of the River Blyth. It was still in use in 1787 and is shown on Gibson's map of that date [3]. This map gives the first composite picture of waggonway development and shows that all the active sea-sale collieries had rail links by that date. There appear to have been about 30 miles (50 kilometres) of main way between Tyne and Blyth with most of the development having taken place in the Wallsend Basin, where fairly short lines linked the new pits there with the river, and in the extreme west, where longer ways linked the outcrop collieries to Bell's Close. Even by 1787, however, certain lines, specifically the Heaton and Cullercoats waggonways, had become disused.

In the second half of the eighteenth century most of the improvements

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1. W.W. TOMLINSON, Historical Notes on Cullercoats (1893), pp 7-12
2. See Figure 16
3. J. GIBSON, op. cit.,

in rail transport involved straightforward material substitution. The age of iron was dawning and the new and more durable material steadily replaced wood in the construction of both permanent way and rolling stock. Fish-bellied rails, cast-iron rails and iron waggon-wheels contributed to the increasing efficiency of the emerging railway. Possibly more important and rather later than this was the revolution in the means of propulsion which began at the end of the eighteenth century. Here the first major advance was the introduction of the self-acting incline by Thomas Barnes at Benwell Colliery in 1797 [1]. This represented the ultimate use of gravity for haulage since no other power was required to move coal from pit-head to staith. It was probably the first instance of a viable method of overland transport which did not depend on muscle power. After all even the barges on the canals were drawn by horses, as were the rolling stock on roads and waggonways. Until that time the improvement of inland transport had been concerned only with permanent way. But here was a new method of transport where the only motive power was gravity. The technique spread rapidly in the coalmining areas and greatly economised the movement of coal [2]. Not only was labour significantly reduced but the inclined plane even had an advantage over steam locomotion in that it required no fuel. Dunn says that it was this development which "... initiated the new era in the overland carriage of coal, characterised more popularly by the steam locomotive".

But the self-acting incline relied on suitable topography and, in the long run, the application of steam-power to surface transport was more important. This innovation belongs to the first two decades of the nineteenth century and is now so well described that it will not be

1. M. DUNN, op. cit., p 52
2. See Figure 29

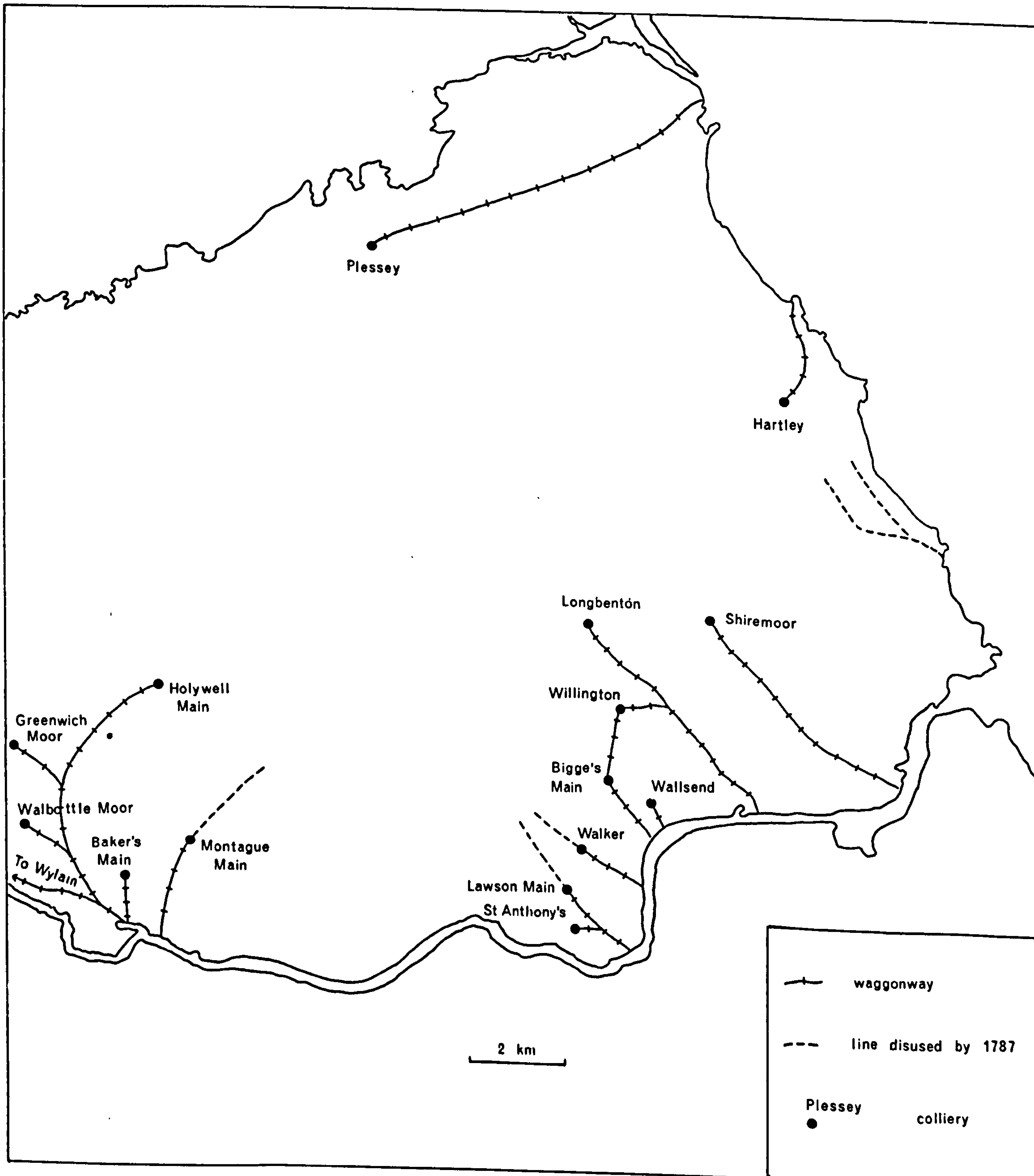

Figure 28 : Waggonways in 1787

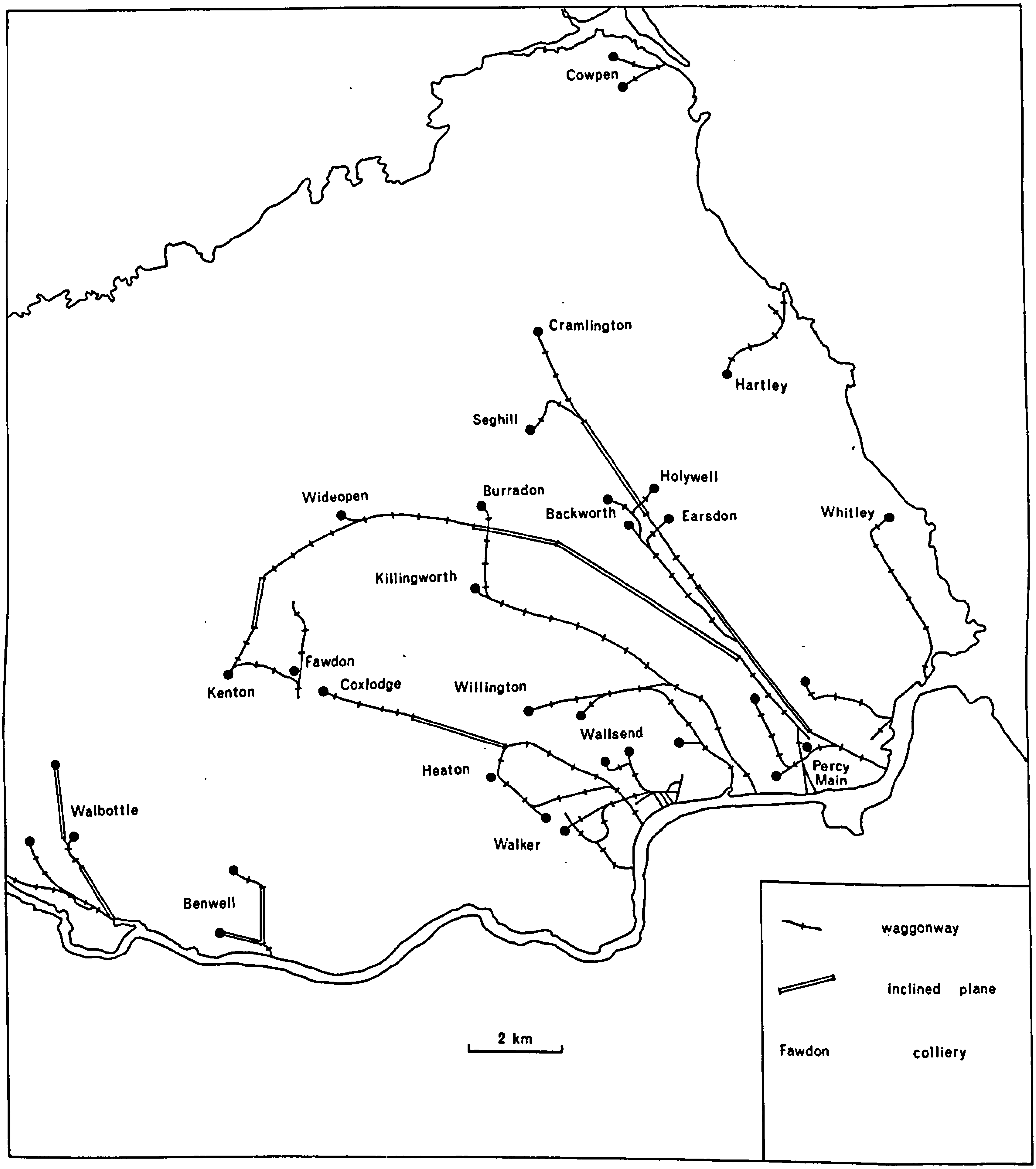

Figure 29 : Surface transport in 1828

dwelt upon at length here. On the waggonways the standing engine, from 1805, and then the 'travelling engine' or locomotive presaged the end of horse haulage and ushered in the age of the railway. The increased efficiency which steam haulage promised is indicated by John Blenkinsop's letter to the owners of Kenton and Coxlodge Colliery comparing the performance of his locomotive with horse haulage [1];

> I write to inform you that my patent steam carriage is daily at work and capable of moving 20 coal wagons each weighing 3½ tons at the rate of 3½ miles an hour ...
>
> | | |
> |---|---|
> | Estimated cost of keeping 81 horses, etc. | £9,453 - 13s |
> | Computed cost of keeping 5 engines | £1,458 - 9s |

Considering that a carriageman had to be paid 2s 10d for every 'gate' (journey) with a single waggon on the Coxlodge waggonway at that time the cost-benefit utility of the innovation was clear enough. It was adopted in 1814 [2].

It is clear that two of the innovations which can be tenuously traced back to Huntingdon Beaumont's excursion to the north in the early seventeenth century had repercussions of great significance. But techniques of boring and waggonways affected only the prospecting for coal and its movement once extracted. There were other areas which were ripe for experiment and innovation. Of these the drainage of workings was especially problematical.

7.4 Mine drainage

By the second half of the seventeenth century the need for a more effective method of pumping was becoming extremely pressing since the

1. NEIMME, Watson Coll., 9/13
2. Ibid.. See pp 168-9

reserves of coal which were above the level of free drainage were becoming steadily exhausted. Of necessity drainage adits were becoming longer and more expensive, involving more hazard. In 1676 Roger North recognised this;

> When they are by the side of a hill they drain by a level carried a mile underground, and cut through the rock to the value of £5000 or £6000 [1].

He also mentions an attempt by Sir Walter Blackett to cut a drift which was foiled by a body of clay and cost him £20,000.

In the later seventeenth century, however, water power appears to have been successfully harnessed for drainage purposes. Once more an accurate understanding of the initial process of adoption is ~~prevented~~ hampered by the absence of primary documentation. But there are numerous references in secondary works to water-wheels in the Ouseburn Valley, draining pits at Heaton and Jesmond, and in Durham at Lumley and Ravensworth. Roger North mentions them and this dates them to before 1676. The machinery at Ravensworth was apparently the most elaborate, Galloway describing it thus;

> The water engines ... were considered to be the most remarkable in the North of England at this time, the total depth was divided into three stages. The water was raised each stage by means of a separate engine and pit. Three water wheels were required, all driven by the same stream; one being placed on high pillars, the second on the surface of the ground and the third under the surface. The power to work the second and third stages was transmitted by means of vertical shafting and wheel work placed in the respective pits [2]

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1. R. NORTH, op. cit., p 174
2. R.L. GALLOWAY, <u>History</u>, p 82

The scale of operations here and the correlation of dates suggests a relationship between this investment in water-power and the early adoption of the waggonway there. The use of water-wheels certainly appears to have been fairly successful and a number of 'bob gins' were in use in the early eighteenth century. A map of Throckley in 1736 shows a reservoir feeding drainage machinery [1]. In 1725 Richard Peck formulated a plan for winning West Hartford Colliery with two bob-gins using water from the River Blyth;

> Make ye dam for taking in ye river with a breast wall ... cutting ye trench 66 yards wch must be five yards broad at ye top and two at ye bottom and three yards deep and may require about 1000 yards of earth to cast up ...
>
> ... to cut ye places for ye two engines must be ten yards broad and nine ye other way and will require at least ye sum of 140 yards of wall for ye wheel case computed at 2s 6d per yd; or 3s ... to a fence wall against ye river and another against ye bank may be about 140 yards of strong wall
>
> There may be other things happen yt. cannot now be thought of that may increase ye expense to £500 [2].

Peck reckoned that such machinery would be capable of lifting the water sixty or seventy feet. The impact of the 'bob-gin' was limited, however, by the fact that it could only be used in localities where streams of sufficient volume could be harnessed and because, from about 1714, it began to be superseded by the atmospheric engine.

Predictably the exact circumstances surrounding the arrival of the atmospheric engine on the Great Northern Coalfield are far from clear.

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1. PRO, MP II/40/25
2. NEIMME, shelf 18, Richard Peck's View Book, pp 36-7

Professor Edward Hughes attempted to elucidate some facts concerning the initial adoption [1]. The conclusion he reaches is that early attempts in Durham were failures because of technical and supply problems but the precise conditions of failure remain a mystery. A number of engines appear to have been erected between 1712 and 1715 but there is no indication as to whether they survived their teething troubles. Hodgson states that

> The first steam engine on the north side of the Tyne is said to have been erected in 1714 at Byker Colliery, the property of Richard Ridley, esq. The engineer was the reputed son of a Swedish nobleman, who taught mathematics at Newcastle [2].

This is yet another tantalising fragment of information handed down from writer to writer but for which no documentary verification seems to exist. In 1734 there were two fire engines at Byker Colliery and a third was being contemplated [3]. The previous year Byker was surpassed in production only by Tanfield which implies a measure of success [4]. It had been mentioned in the list of Tyne collieries working in 1724. It is tempting to believe that steam pumping had survived from 1714 but the absence of real continuity in the evidence is perplexing.

Despite this there are strong grounds for asserting that the Ouseburn Valley was the scene of the first successful application of the atmospheric engine. It is certain that by 1735 there were at least eight engines at work there. But it is difficult to ascertain exactly

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1. See pp 96–8
2. NEIMME, Bell Coll., vol I, p 504; a cutting from 'Akenhead's Picture of Newcastle'.
3. NEIMME, shelf 18, Richard Peck's View Book, p 72
4. NEIMME, shelf 18, Grand Allies Minute Book, pp 82–3

when these engines were erected. In the case of Heaton the first of its four engines was erected about 1727, since the colliery began to be won in 1725 and the winning was completed two years later [1]. In 1733 Richard Peck supplied the dimensions of "the old Engine Boyler" at Jesmond. But he may not have implied antiquity by this. Since a second engine was about to be erected there he may simply have been contrasting the existing engine with the new. But Jesmond produced 12,000 chaldrons in 1726 and there were four working pits ranging between 39 and 42 fathoms in depth [2]. It seems more than likely that these relatively deep pits were won with the aid of an atmospheric engine - the 'old engine' referred to by Richard Peck. It would not be stretching the evidence too far to say that the atmospheric engine was successfully employed in the Ouseburn Valley from at least the early 1720s.

It is noteworthy that at the parliamentary enquiry in 1738 the only engines mentioned were those in the Ouseburn Valley. Thomas Stokoe, when asked whether it would be possible to open collieries nearer to the river in order to avoid transport costs and wayleave problems, replied

> ... I believe several may be won that lie near the river ... there are no levels and they cannot be won without fire engines but they do the same at Heaton [3].

Another witness, George Claughton, said of the engines, "... They cost at first £1200 and about £400 a year maintaining"; and of Jesmond Colliery, "... She was very expensive at first, but is not so now" [4].

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1. See p 103 and Figure 33
2. NEIMME, shelf 18, Richard Peck's View Book, pp 31-5, 45
3. NEIMME, Buddle Coll., vol 14, pp 354-5
4. Ibid., p 363

It was the level of investment required for the adoption of the atmospheric engine which was initially so discouraging. Consequently it was probably not until about 1735 that their economic viability was proven when the profitability of Jesmond and Heaton began to improve.

Nevertheless it is certain that by 1740 the atmospheric engine had been accepted as a means of draining coalmines and it was soon to become indispensable to the larger, deeper winnings. In that year Amos Barnes produced a computation and comparison of the cost of winning Gateshead Park and Longbenton Collieries, presented here as Table 18. This is an excellent illustration of the way in which the balance of advantages weighed in the mind of the viewer. Gateshead Park clearly had an edge in winning and surface transport but Longbenton was cheaper to work. Another factor which may have counted in Longbenton's favour was that 'fire engines' held their value since they were, to some extent, movable (new collieries often bought their cylinders from collieries which had recently closed) whereas investment in drifts, shafts and staiths, once expended, could not be recovered.

Only a month after he had made the estimate for Gateshead Park and Longbenton, the same viewer was asked to consider the expense of winning Elswick Colliery. His calculation totalled £2,300 and included two atmospheric engines costing £2,000 [1]. It is thus clear that the cost of this relatively sophisticated machinery had become the major item of expense in winning collieries.

From this time onwards the efficiency of steam-powered technology increased steadily. Jevons calculated the duty of the engine after various improvements, providing the following figures of coal

1. NEIMME, T.E. Forster Coll., 49/4, p 56

TABLE 18 : A comparison between Longbenton Colliery and Gateshead Park Colliery; the cost of winning and working, 1740

The winning of the collieries:	
Longbenton	£6,820
Gateshead Park	£6,600
The main items of expense at Longbenton:	
One double engine pit, 70 fathoms	£800
Another engine shaft	£500
3 fire engines	£3,600
5,000 yards of waggonway	£1,500
The main items of expense at Gateshead Park:	
A drift	£1,500
One double engine pit, 49 fathoms	£700
2 fire engines	£2,400
15 keel berths and trunk	£1,600
The leading of coal:	
Longbenton	£1 - 7 - 6 per chaldron
Gateshead Park	£0 - 5 - 6 " "
Water charge:	
Longbenton	£0 -12 - 0 " "
Gateshead Park	£0 - 8 - 0 " "
Ways and waggons:	
Longbenton	£0 -16 - 0 " "
Gateshead Park	£0 - 8 - 0 " "
The working of the colliery:	
Longbenton	£0 - 5 - 1½ per score
Gateshead Park	£0 - 5 - 7 " "

Source: NEIMME, T.E. Forster Coll., 49/4, pp 54-5 consumption per horse-power per hour [1];

1769	30	lbs of coal
1772	17.6	"
1825	10.0	"
1850	5.9	"
1875	2.5	"
1900	1.0	"

But the duty of an engine is not directly related to capacity since it is a measure of fuel efficiency. Obviously running costs, in terms of coal consumption, were not of paramount importance to the collieries. Their main concern was with capacity; whether the engine was capable of keeping down the water in the sumps or not. At first the only way of increasing horse-power was by increasing the scale of machinery, either by using more than one engine or by using bigger engines. Table 19, and its cartographic representation in Figure 30, show the deployment of atmospheric engine-power in Northumberland in 1769. The engines which by then were being adopted to win the deeper collieries around the periphery of the Wallsend Basin appear to have been two or three times larger than the earlier ones.

At first most atmospheric engines in the north seem to have employed a cylinder of between 30 and 42 inches (76 and 107 cm.) diameter. The cylinders also seem to have been supplied by the Coalbrookdale foundry and were probably shipped round the coast from the Severn. In 1738, when George Claughton was asked whether it was possible to erect an engine for less than £1,200, he said

1. W.S. JEVONS, op. cit., pp 144-8

TABLE 19: Atmospheric engines at work drawing water in Northumberland in 1769

Colliery	Number of engines	Cylinder size (diameter in inches)
In Northumberland, between Tyne and Blyth:		
Benton	5	60
Benwell	1	75
Byker	6	60,42,42
Chirton	1	42
East Denton	1	60
Elswick	2	28,27
Gosforth	1	
Hartley	2	62,42
Heaton	4	
Jesmond	4	
Lemmington	1	42
Newbiggin	4	60,44,42,42
Newburn	1	
Plessey	1	32
Throckley	4	60,48,36,13
Tynemouth Moor (Shiremoor)	4	75,70,60,42
Walker	2	73,72
West Denton	2	38,36
Wylam	2	60,47

There were 49 other engines listed, mainly at collieries in Durham and Cumberland.

Source: NEIMME, 'Dunn's History of the Viewers', p 14

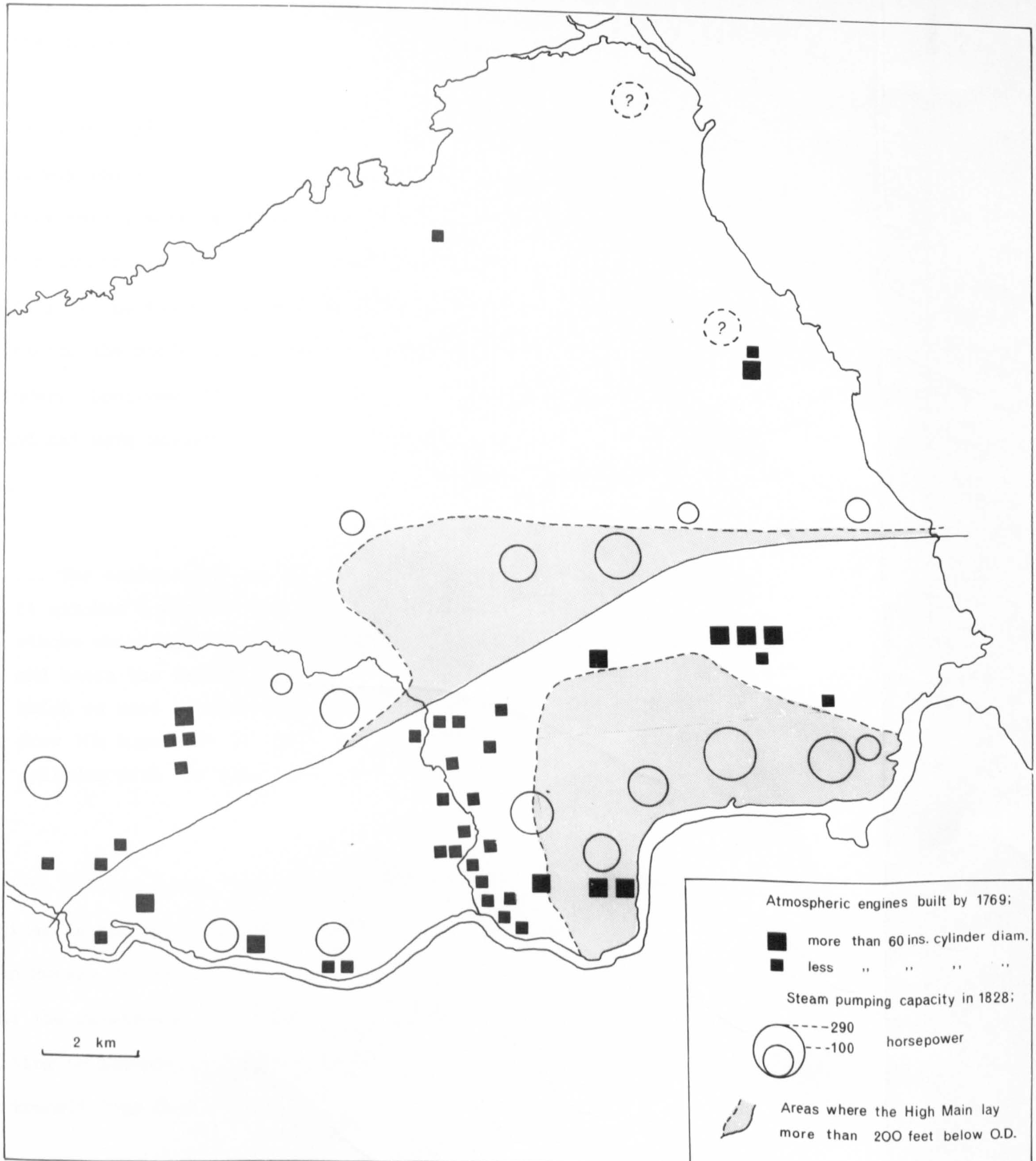

Figure 30 : The location of pumping capacity

> ... They may have a bad one for 8 or £900 but I don't know they can have a good one of 32 inches diameter for less than £1,200 [1].

But the tracts of coal which could be won with such machinery were relatively small. For this reason large collieries like Jesmond, Heaton and Longbenton, working before 1750, found it necessary to erect three or four atmospheric engines. It was soon discovered, however, that the capacity of the engine for drawing water could be improved simply by increasing the scale of the machinery, and particularly the size of the cylinder. Consequently in the 1750s and 1760s a number of 'great cylinders' were harnessed. In 1755 at Chirton Colliery it was observed that

> ... The engine with the present cylinder 36 inches diameter goes 11 strokes a minute with a nine inch barrel and 6ft. 6 inch stroke which will draw 230 hogsheads 30 gallons in an hour ... and beats the feeder ... if a cylinder 50 inches diameter, which we have lying by us, was put in the Great Cylinder will draw 104 hogsheads 48 gallons in an hour more than the little cylinder with the same pumps and stroke [2].

In 1761 William Brown, who played a major role in the erection of engines in the north at this time, wrote to his employer, John Hussey Delaval, owner of Hartley Colliery. In January of that year the re-winning of the colliery was well in progress and Brown was waiting to install an engine of 60 inches (152 cm.) diameter which was in transit from Coalbrookdale.

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1. NEIMME, Buddle Coll., vol 14, p 363
2. NEIMME, Watson Coll., 9/18

> As has no account of the cylinder being shipp'd trouble you with this to acquaint you that we are in great want of it for has got the upper sett of 18 inch iron pumps in and completely fix'd at 2 fathoms below the 5 Quarter coale & the other day got the lower sett to work but the present cylinder has not the power to work them more than 5 or 6 strokes a minute nor will we be able to sink more than 2 or 3 fathoms further till gets the great cylinder from which may judge of the disagreeable situation we are in for want of her ... The boiler at the old engine has now burst several times of late and by that engine standing the water is not kept down in the Venture Pit so low as it ought & several bords is now drown'd [1].

By April, however, the cylinder had arrived and Brown was able to report

> ... After much expectation we have at last got our great cylinder she will be in her place tomorrow & I think in ten days everything ready to get to sink again; we have got much deeper than I ever expected with the little cylinder tho' it has been expensive [2].

It was only two years later, in 1763, that

> ... The cylinder of Walker Colliery arrived from Coalbrookdale; diameter 72 inches, length of stroke 10½ feet; being the largest in the north of England [3]

It was described as the "most noble and complete piece of ironwork". It appears that it was not the initial introduction of the atmospheric

1. NRO, Delaval Coll., 2/DE 6/3
2. Ibid.
3. M. DUNN, op. cit.,

engine which made possible the winning of the Wallsend Basin but the enlargement of its scale of operation. Engines like that at Walker were more than twice as large as those used in the Ouseburn Valley thirty years before.

By the end of the century a large winning would expect to employ initially a main engine of 100 horse-power with another smaller engine used for peripheral winning or held in reserve. By 1828 there were 2,333 horse-power expended by steam engines draining the collieries between Tyne and Blyth [1]. The engines at Friar's Goose alone raised a thousand gallons per minute [2].

7.5 Improvements underground

It is now clear that enormous technical strides were made in the drainage of mines, prospecting for coal and surface haulage and these were an integral and indispensable part of the development of the Great Northern Coalfield, possibly of the industrial revolution in Britain. There were other areas, however, where new technology was also necessary, notably in ventilation and underground haulage. Although these stimulated no great innovatory break-throughs there was a gradual improvement in underground methods without which the benefits of the boring rod, the waggonway and the steam engine may have been jeopardised. At any rate, without such improvement, the great expansion which took place in the scale of operations underground would not have been possible.

The ventilation of coalmines was necessitated by the presence of two gasses underground which, during the development of the coal industry, took a fearful toll of human life; 'fire damp' or carburetted hydrogen

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1. See Table 12 and Figure 30
2. W.S. JEVONS, op. cit., p 71; See T.J. TAYLOR, op. cit., p 46

was responsible for explosions and 'choke damp' or carbonic acid gas caused asphyxia. For the miner these, together with innundation and roof collapse, were the main hazards underground. Their occurrence varied greatly from pit to pit but, generally, the further workings penetrated the greater was the risk. There was also a weather factor. Hot weather led to a temperature inversion within the shaft and the normal tendency for air to rise up the shaft was interrupted leading to stagnation. Cool, breezy weather made conditions underground more comfortable. An analysis of a list of more than seventy explosions in coal mines, causing an aggregate loss of nearly one thousand lives shows this relationship: [1]

Winter	8	explosions
Spring	13	"
Summer	20	"
Autumn	30	"

In the relatively shallow mines of the early seventeenth century the coal faces were seldom any great distance from the shaft bottom and the use of adits for drainage also enabled some circulation of air. Since the workings were no great distance from the surface 'staples', a type of smaller vertical shaft, were also sunk to increase the draught underground [2]. Consequently, with 'pit and adit' working, ventilation was not usually a serious problem and where it was miners sometimes resorted to the common bellows. From the later seventeenth century, however, with the arrival of water - and later steam-power, and the extension of underground working, the need for effective ventilation became more

1. NEIMME, Bell Coll., vol II, p 105
2. See Figure 14

pressing. In 1676 Roger North observed

> Damps or foul air kill insensibly; sinking another pit that the air may not stagnate is an infallible remedy. They are most affected in very hot weather [1].

But, in fact, there was no "infallible remedy". The record of tragic accidents caused by inadequate ventilation bears witness to that. The seriousness of these varied considerably. Some caused great destruction, loss of life and attracted considerable public attention, such as that at Lambton Colliery in 1766 when

> ... The men below were drove by the force up through the shaft or great tube, like balls out of a cannon, and everything that resisted shared the same fate. The neighbourhood being alarmed collected itself in order to give assistance; but found only heads, arms and legs thrown out to a great distance from the mouths of the pits [2].

Others crept anonymously onto the continuing casualty list which recorded the sacrifice to be paid for coal. John Watson records in his diary an incident at Longbenton Colliery in 1749;

> Meadow pit off work owing to 4 men being burnt from putting their candles too near the roof ... two of the men were sore burnt, the other two but slightly [3].

Of course, inadequate ventilation was only part of the problem. The

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1. R. NORTH, op. cit., p 173
2. NEIMME, Bell Coll., vol I, p 501
3. NEIMME, Watson Coll., 8/4 , p 88

fact that miners had to use ordinary tallow candles for light provided ready ignition wherever the gas collected underground. In deep mines the dangers were enormous and technology was slow to respond. The invention of the steel-mill by Carlisle Spedding at Whitehaven evoked only premature hope and further disaster. Many hundreds of lives were lost (600 on the Tyne and Wear in 1813-14 alone) before the safety-lamp was invented by Stephenson and Davy.

The introduction of 'lamps' (braziers of burning coal), according to Dunn by Edward Smith at Chartershaugh Colliery in 1732 [1], served to increase the draught between the 'downcast' and the 'upcast' shafts. At first these were placed at the bottom of the 'upcast' shaft. This was not entirely convenient, however, as one viewer commented;

> Went down the Lane Pit which is 65 fathoms deep. A large lamp stands at the bottom of the shaft which they keep in continual blaze for the convenience of air & c. which makes the shaft as bad to ride as a Kitchen chimney [2].

The placing of large fires at the bottom of the shaft was obviously fraught with problems and dangers. Consequently, large furnaces sited at the top of the shaft were adopted in addition or instead. The use of 'brattices' and 'stoppings', which were partitions of wood and brick-work respectively, accompanied the introduction of 'coursing' to ventilation and greatly facilitated the underground extension of workings. In 1804 it was calculated that the air in Hebburn Colliery travelled thirty miles underground before ascending the 'upcast' shaft.

As far as the methods of working and transporting coal underground were

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1. M. DUNN, op. cit., p 48
2. NEIMME, Watson Coll., 8/4, p 34

concerned technological progress was surprisingly slow. The wasteful 'bord and pillar' method survived the whole period here under consideration; only by about 1840 did the longwall method begin to supersede the older system in the north. The labour of the hewer at the coal-face changed hardly at all. The replacement of the sledge by the four-wheeled tram running on a wooden tramway (the underground application of the principle of the waggonway) greatly increased the effectiveness of the barrowman's unenviable toil. Later the substitution of horse for human muscle in the movement of coal to the shaft bottom along 'rolley ways' was another important step. The efficiency of both these kinds of railed way was greatly increased after 1776 when John Curr, a Tyneside viewer who had moved south to work in the Duke of Norfolk's Sheffield collieries, pioneered the use of cast-iron rails underground [1]. Despite the greatly increased use of 'galloways' (ponies), however, large numbers of men and boys continued to be employed in the movement of coal underground as barrowmen, putters, drivers, shifters, cranemen, trappers, wastemen and onsetters. Even in 1844 the persons employed in this capacity usually outnumbered those actually hewing coal at the faces, and this despite a great increase in the use of horses underground [2]. The depth of workings, which meant that normally only one pit was used for drawing at each colliery, combined with the great distance of the faces from the shaft bottom was chiefly responsible.

The substitution of horse for human muscle was crucial to the expansion of underground working. But this required considerable modification of existing techniques. Rolley ways, which were virtually underground waggonways, needed to be larger and more regular than the old headways

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1. M. DUNN, op. cit., p 50
2. See Table 24

along which barrowmen could work. Horses were very sensitive to changes in gradient. In 1807 Buddle observed that where

> ... the rise exceeds an angle of 8 degrees I do not think galloways can be advantageously applied to inbie putting. At a rise of 5 degrees a horse will not do so much work by 30 per cent, on the average, as on the level; at a rise of 10 degrees he will not do as much work by 50 per cent; and I believe that a horse cannot possibly be applied where the rise is more than 12 degrees, but in that case barrowmen would do the work much cheaper [1].

But there were other countervailing considerations favouring horses;

> Owner can command the work of the horses with a degree of continuity not to be reckoned upon where boys only are employed in that species of work [2].

Since considerable sums of money had to be spent regularising and levelling rolley ways before horse haulage became efficient it was generally only justifiable for the main arteries of underground transport. Older boys continued to 'put' coal from the coal faces to the rolley ways for a century after 1850.

There was one facet of underground haulage in which, because the need was more pressing and the challenge greater, technological progress was more impressive. This was drawing. The increase in the scale of working underground, which accompanied more elaborate drainage operations, in the second half of the seventeenth century soon rendered the simple 'jack-roll' inadequate as a means of raising the corves of coal up the

1. NEIMME, Watson Coll., 9/13
2. NEIMME, Buddle Coll., vol 3, p 68

shaft. The initial substitution of horse for human labour was an obvious step since there was a close correlation with drainage. Even in 1708

> ... if a pit is sunk more than thirty fathoms, then we use the horse engine, which engine being wrought with one or two horses at a time serves also to draw up the wrought coals [1].

The 'cog and rung' gin and its modification the 'whim' gin were used until the later eighteenth century;

> ... in a pit 40 fathoms deep eight horses were required every day to draw 21 scores of coals (about 90 tons) ...[2]

In 1752 at Longbenton Colliery, then about the largest, there were 54 gin horses in all, comprising six teams of nine. Each pit had two teams and each team worked for five hours per shift, running twenty miles in the process [3].

By the middle of the eighteenth century, however, an important innovation was beginning to supersede the use of gins for drawing. Curiously, it represented a reversion to water power which had been replaced in drainage by the atmospheric engine. In fact, it was the use of water-wheels fed by the water being pumped to the surface by the atmospheric engines. The idea is attributed to Smeaton but Agricola had described both single and double bucket wheels used in Germany at the end of the sixteenth century [4]. Two references in George Johnson's

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1. J.C., op. cit., p 28
2. T.J. TAYLOR, op. cit., p 35
3. NEIMME, T.E. Forster Coll., 49/4, p 109
4. T.J. TAYLOR, op. cit., p 39

diary show that such wheels were making an impact by 1752;

> Mr Henry Atkinson and self rode out this morning to Fenham, from thence to Newburn where we dined at Mr Brown's who happened not to be at home. After dinner we rode to see his new machine which he has for drawing water and coals at one time, find it works three spears and three cranks, each crank standing at an angle of 120 degrees from ye other so that ye spears work very smooth and regular and from thence we crossed the Tyne and rode to Ryton [1].

On May 10th the following year Johnson rode to West Denton;

> saw Mr Robert Beaumont's machine for drawing coals by a fire engine and water wheel which I think is a very pretty contrivance [2].

From this time the water-wheel was widely used for drawing coal. It was only a short time after that, however, that viewers begun to experiment to find a means of applying the steam engine directly to drawing. In 1763 Joseph Oxley, then an employee in a Newcastle factory, took out a patent "... for drawing coals out of the pits without the employment of horses" [3]. He built two engines at Hartley, the second being more successful, drawing 30 scores in 24 hours and provoking a visit to the north by James Watt. But engines of Oxley's design do not seem to have made a great impact. It was not until the 1780s that other attempts were made to harness steam engines for winding and these were

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1. NEIMME, Johnson Coll., 4/3, p 97
2. Ibid., p 131
3. Northumberland County History, vol VIII, p 24
   See also NRO, Delaval Coll., 2/DE 6/4 which suggests that one of Oxley's engines was working quite satisfactorily in 1766.

engines of improved Boulton and Watt design. A patent was granted to Cameron, Blair and Jeffreys, suppliers of Boulton and Watt engines, for the invention of a machine for raising coals on January 28th, 1786 [1]. The first 'machine' began drawing coal on December 12th, 1787 (and not as Dunn claims at St Anthony's Colliery in 1790) at Bigge's Main Colliery [2]. In 1789 Cameron wrote to an associate that one of his Newcastle engines raised 300 tons of coal per day from 95 fathoms. But these early attempts seem to have met with considerable difficulty and it was not until 1795 that orders for winding engines for Tyneside collieries began to reach the Soho factory regularly [3]. It was Thomas Barnes, the famous viewer of Walker and Benwell, who promoted their initial adoption. In 1795 he ordered engines of 'sun and planet' design for both Benwell and Walker. In the following year there were five winding engines ordered by the larger collieries in the Wallsend area [4].

In 1795, J. Southern wrote to Matthew Boulton describing the engine at Benwell;

> The corf at the bottom of the engine sets off, the engine checks itself before it comes to meetings (which is necessary on account of the great velocity of the corf) it afterwards resumes its speed till it comes near the top when it slackens its velocity till it arrives at the top.

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1. NEIMME, Watson Coll., 9/4
2. Ibid.
3. H.W. DICKINSON & R. JENKINS, James Watt and the Steam Engine (1927), pp 253-5
4. Birmingham Reference Library, Boulton and Watt Coll., Catalogue of Old Engines, pp 45-6

On February 12th, 1796 James Watt, Junior, visited Benwell himself;

> I will no longer defer expressing the pleasure I received from seeing your contrivances at Benwell. The first time we tried the engine it performed admirably, executing all its evolutions with the greatest regularity and precision, first at the rate of a corf in 50 and then in 40 seconds [1].

Since the Charlotte Pit was 98 fathoms deep, in this latter instance the corf, weighing almost a quarter ton, was travelling against the direct pull of gravity at a speed of about ten miles per hour. The Boulton and Watt winding engine, or 'machine' as it was popularly called, was widely adopted from this time onwards. It completed the transformation of coalmining by steam power which had taken eighty years.

7.6 <u>The changing scale of operations</u>

The unit of production in coalmining (except where opencast) is the pit and its workings. The size of this unit has changed enormously, progressing from the 'bell pit', a few feet deep with workings a few yards from daylight, to the modern colliery, with a shaft thousands of feet deep and coal-faces miles from its bottom. In spatial terms the scale of operations has been increased both in the vertical plane, by pits penetrating to greater depth, and in the horizontal plane, by the extension of underground workings. At the same time, even in the earliest documents, the organisation responsible for coal production is referred to as a 'coalery'. But before the nineteenth century the concept of the colliery was never synonymous with the unit of production although, since collieries evolved to have one or two pits, and therefore to be locationally stable at the surface, the words pit and colliery have

1. H.W. DICKINSON & R. JENKINS, op. cit.

come to mean much the same thing in common parlance. All along there has been an element of ambiguity as to whether a colliery is a physical or an organisational phenomenon. In the days of private ownership the individual colliery could be distinguished either by owner or by geographical location, hence names like Percy Main, Montague Main and Bigge's Main, on the one hand, and Walker, Wallsend or Hartley on the other.

In Chapter One the scale and nature of coalmining in Benwell in the first half of the seventeenth century was elucidated [1]. There is no reason to suppose that the nature of the pits and workings at Benwell was essentially different from the norm. The average pit at that time was thus about 100 feet (30 metres) deep with workings which extended up to 100 yards (90 metres) from the bottom of the shaft. It employed nine hewers, and therefore probably about twenty-five or thirty persons underground, and raised four hundred basketfuls of coal every work day. Each basket held about 250 lbs.(112 kgs.) of coal. A day's work therefore produced about 40, a year's work about 12,000 tonnes of coal. At Benwell the whole colliery was owned and financed by a partnership of Newcastle Hostmen but each pit was in the charge of an overman who organised actual coal extraction. Thus, in 1617, John Osborne

> ... wrought one pitt in Stumplewood for Sit Peter Riddle & his ptners. and cast out of the same eight tenns of coal or thereabouts for which the said Sir Peter paid ... fower nobles for every tenn for the workinge of the same [2].

By the standards of succeeding centuries such pits were very short-lived.

1. See pp 67-72
2. PRO, E 134/12 Car I/East 25

Some of those at Benwell seem to have had a lifespan of about six months.

In 1700 the number of corves raised per day, ranging from about fifteen to about twenty-five scores, does not appear at first glance to be substantially different [1]. But there had almost certainly been some change in the scale of production owing to the increased size of the corf. Corves of six and eight pecks capacity were used at Benwell in the early seventeenth century. By 1720 corves of twelve, thirteen and sixteen pecks were in use at Newbiggin and Elswick [2]. The sixteen-peck corf became standard at most pits during the rest of the eighteenth century but, by the nineteenth, eighteen and twenty-peck corves were being adopted. By the middle of the nineteenth century corves were being replaced by tubs for underground carriage but, before then, thirty-peck corves had been used at some collieries. As more powerful machinery for drawing was harnessed economies of scale demanded a larger corf. In 1807 Kenton and Coxlodge Colliery was contemplating the purchase of one of Boulton and Watt's steam engines for winding;

> At present they are working about 12 score of 24 peck corves each shift at the Engine Pit, the machine is supposed to be able to draw 20 score of 24 peck corves in the 12 hours, the pit is in depth 102 fathoms [3].

Thus the Engine Pit at Coxlodge, with steam winding machinery, was capable of drawing 9,600 pecks of coal in twelve hours. The pits at Benwell were drawing about 3,200 pecks of coal in a working day (probably considerably longer than twelve hours). But the Engine Pit

1. See Table 4
2. NEIMME, shelf 18, Richard Peck's View Book, p 28
3. NEIMME, Watson Coll., 9/13

was about six times deeper than the Benwell pits. The operating capacity of the pit at Coxlodge in 1807 therefore seems to have been eighteen times greater than at Benwell in the 1620s.

It is tempting to presume that by 1700 the scale of operations at the average pit must have been substantially greater than it had been eighty years previously at Benwell. But the description of pits sunk in the fields of South Hartley Farm between 1695 and 1725 suggests that the nature and scale of mining there was not substantially different from that at Benwell a century earlier [1]. Figure 14, however, shows Benwell Colliery as it was in the period before 1722 and suggests a rather larger unit of production. Here it is necessary to recognise and emphasise that a larger unit of production was not simply the natural and inevitable corollary of improved technology. The extent of a pit's workings was also related to the depth of the seam from the surface. Sinking was one of the most expensive items of capital expenditure in winning. With deeper seams it became necessary and economical to minimise the number of sinkings, to make the area of coal worked from each pit shaft as great as possible. But for the outcrop collieries, working thinner seams at shallower depth, the advantages of more extensive and complicated underground workings, remained less obvious. These continued to sink more pits and maintain a smaller, technologically less complex unit of production than the deeper collieries [2].

Increasing the arena of working underground must have been difficult so long as the movement of coal depended entirely on human labour. It was the arrival of the tram with flanged wheels running on rails, replacing

1. See p 210
2. This explains the large number of pits sunk by Callerton and Throckley Collieries in the second half of the eighteenth century. See pp 144-6

sledges, and, more importantly, of the rolley-way with horse haulage which allowed a great extension of the area of underground working away from the parent shaft. In Northumberland this accompanied the winning of the deeper High Main, east of Newcastle, after 1725. In 1752 the two working coal pits at Longbenton Colliery, the Lane and the Meadow, had 37 and 41 underground horses respectively and there were 54 gin horses employed in drawing [1]. In 1750 the workings of the Lane Pit were 320 yards (291 metres) from the shaft bottom (equivalent to sixteen barrowmen rank). Each pit was working sixteen to eighteen scores of sixteen-peck corves per twelve-hour shift. The Lane Pit was 57 fathoms in depth and the Meadow Pit 58 fathoms. The yearly production of the colliery as a whole varied from 1,200 to 2,000 tens (of 420 bolls) between 1745 and 1753 [2]. Taken together and compared with the data for Benwell these facts suggest a considerable increase in the scale of operations and in the size of the unit of production by 1750.

Figures 31 and 32 show the pattern of production for Jesmond Colliery between 1742 and 1745 and for Walker Colliery between 1800 and 1805. The Jesmond pits were 40 to 50 fathoms deep, those at Walker over 90 fathoms. In 1742 the Chester Pit, most prolific of those at Jesmond, yielded 4,855 scores of corves [3]. During 1803 the King Pit at Walker produced 9,197 scores [4]. This evidence suggests strongly that by the end of the eighteenth century the scale of production at the individual pit was much larger. Indeed the situation had almost been reached whereby underground haulage had been so improved that a large royalty could be worked from a single pit. According to Buddle a number of

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1. NEIMME, T.E. Forster Coll. 49/4, p 110 Johnson Coll., 4/3, p 65
2. NEIMME, Watson Coll., 11/54
3. NRO, Ridley Coll., ZRI/35/13
4. NEIMME, Buddle Coll., vol 5, pp 1-19

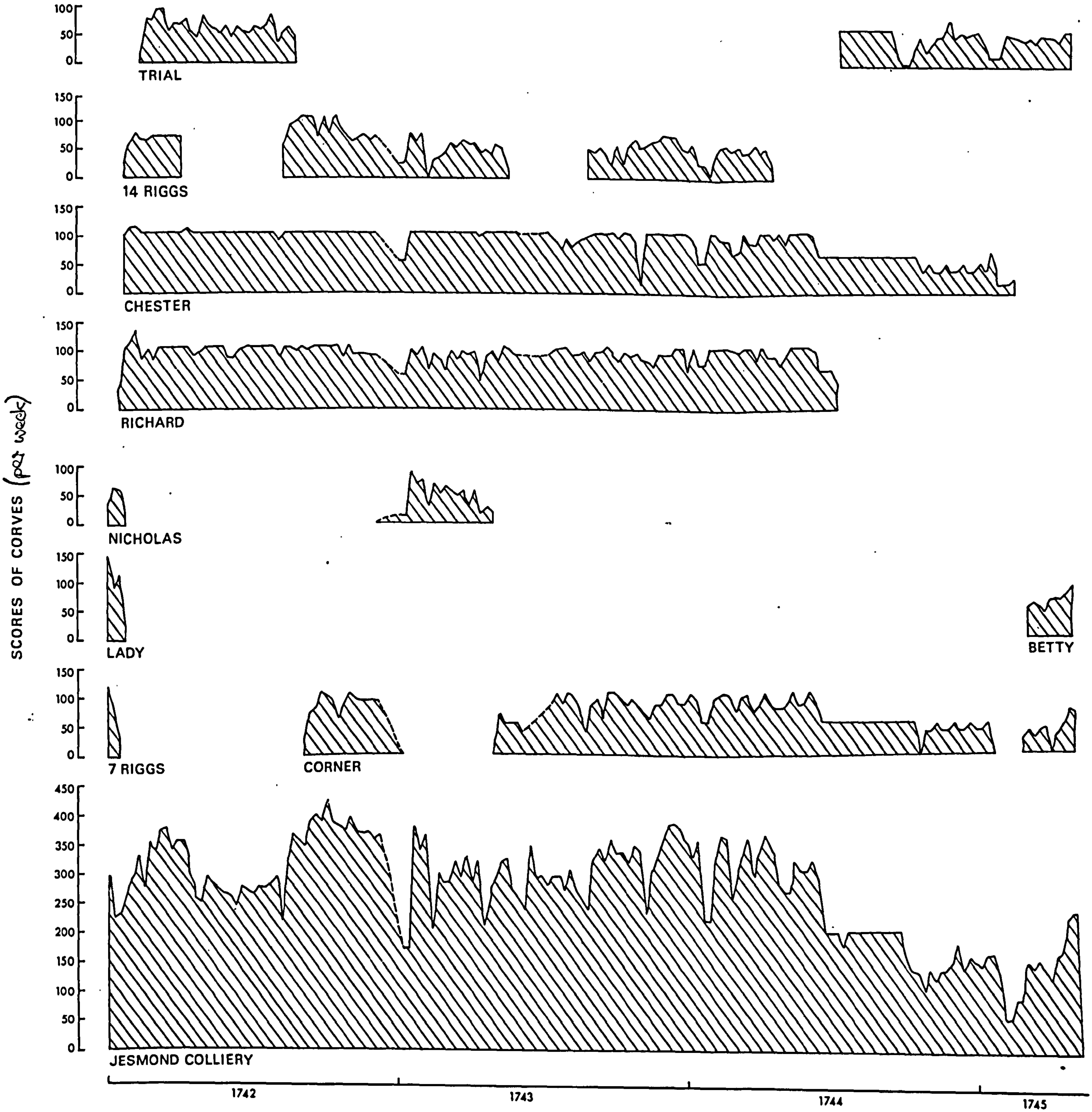

Figure 31 : The pattern of production at Jesmond Colliery, 1742 to 1745

Figure 32 : The pattern of production at Walker Colliery, 1800 to 1805

collieries - Cramlington, Whitley, Holywell and Benwell - were won and worked from only one pit by 1828 [1]. After the Hartley Colliery disaster of 1862, however, the Duplicate Shaft Act required all coal workings to have access to at least two pit shafts.

The impression given by descriptions of collieries such as Benwell in the first half of the seventeenth century is that winnings were limited in scope and that the lack of a clear understanding of the extent and disposition of seams discouraged long-term planning. It may be that the disorderly presentation of evidence in surviving documentation contributes to this impression and it is conceivable that the speculators themselves were more far-sighted than appears. But before boring had made possible preliminary underground exploration long-term planning must have been hazardous and pits could only be sunk safely in proximity to existing workings. In essence, therefore, extraction proceeded centrifugally or, where geological conditions were variable, followed the line of least resistance (and least working cost). The choice of new locations for mining included only those areas adjacent to former workings where subterranean conditions could be predicted with some certainty. With preliminary exploration by boring, however, the area of choice and the ability to plan ahead were increased.

In 1675 Martin Fenwick began the winning of Kenton Colliery and it was continued by William Blackett until it was drowned by "an overcharge of water" in 1716 [2]. In 1732 Ralph Burn and Ralph Wonders, probably former employees of the colliery, recorded an accurate description of the winnings there [3].

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1. See Table 12
2. NEIMME, T.E. Forster Coll., 49/4, p 37
3. NEIMME, shelf 18, Richard Peck's View Book, p 64

Beginning at Slatyford Gins ...
1st is the Boreing Pitt wch. was 60 fathoms to the Main Coale from which ye watter level came; from which ye watter was lifted 21 fathoms to Tyne Level.
2nd is the Swang or Outgin pitt wch. was to ye Maine Coale 55 fas. The water level from the Boreing Pitt is under ditto 25 yards.
3rd is the Quarryhead Pitt wch. is to ye Maine Coale 58 fas. This pit is 28 yards under the water level from wch. pitt a stone drift was drove to ye said level.
4th is the Heavermeall Pitt wch is to the Maine Coale 55 fathoms. The water level is under ditto 40 yards.
5th is ye West Blakelaw Pit wch. is to ye Maine Coale 60 fathoms. The Water level is under ditto 5 yds.
6th is the East Blakelaw Pitt wch. is 60 fas. to ye Maine Coale. The water level is under ditto 5 yds.
7th is the Broom Close Pitt wch is 60 fathoms to ye Maine Coale. The water level is under ditto 3 yds.
8th is the Towngate Pitt to ye Maine Coale is 44 fathoms. The water level is under ditto 40 yds.
N.B. The above pitts are all that's on ye South Side the Town (i.e. Kenton village) called watter levell pitts: in Lilburn's liberty.

Water levell pitts on the North side of Kenton in Mr Blackett's Liberty:
1st The Quarry Close pitt to ye Maine Coale is 38 fathoms. The water level under ditto 30 yards.
2nd The Corner Pitt in the Wheat Close to ye Maine Coale 32 faths. The water level under ditto is 10 yds.
3rd Barker's Close Pitt to the Maine Coale 26 fas. The water level is under ditto 20 yds.
4th The first Fatting Pasture Pitt to ye Maine Coale 26 faths. (heapstead ledaway) The w.l. under ditto 21 yds.
5th The second Fatting Pasture Pitt to ye Maine Coale is 27 fathoms. (At this pit they lifted the water 11 fathoms into a stone drift which was drove from ye Bank Pitt along which the water went away at Tyne Level)

6th The Cadwell Pitt to ye Maine Coale 24 faths. The water level under ditto is 6 yds.

Water levell Pitts on the north side of the Town in Lilburn's liberty.

1. The third Chester Pitt next the wattergin joyning ye Bounder hedge E. of W. Kenton, to ye Maine Coale 29 fathoms.

N.B. ye gin lifted ye watter 10 fathoms; the watter leavell under ditto 3 yds.

2. The 2nd Chester Pitt to the Maine Coale is 26 fathoms. The watter leavell under ditto is 30 yards.

3. The 1st Chester Pitt to the Maine Coale is 26 fathoms. Watter leavell under ditto is 35 yards.

4. Bares poole Pitt to ye Maine Coale 20 fathoms. Watter leavell under ditto 50 yards.

When the above description is considered in combination with William Brown's later survey of the colliery [1] it appears that a large and flourishing enterprise was sustained perhaps for some forty years. Some of the pits were very deep for that time and the name of the first mentioned above suggests a significant contribution by new prospecting technology. It had a four-mile waggonway link to a staith at Scotswood which must have been one of the earliest wooden railways in the county [2]. It seems that the main winning was made at Slatyford, with gins used to raise water into an adit whence it was delivered via Benwell waste to the Tyne. The resultant lowering of the local water table laid dry enough High Main Coal - 560 acres according to Brown - to justify the sinking of eighteen pits.

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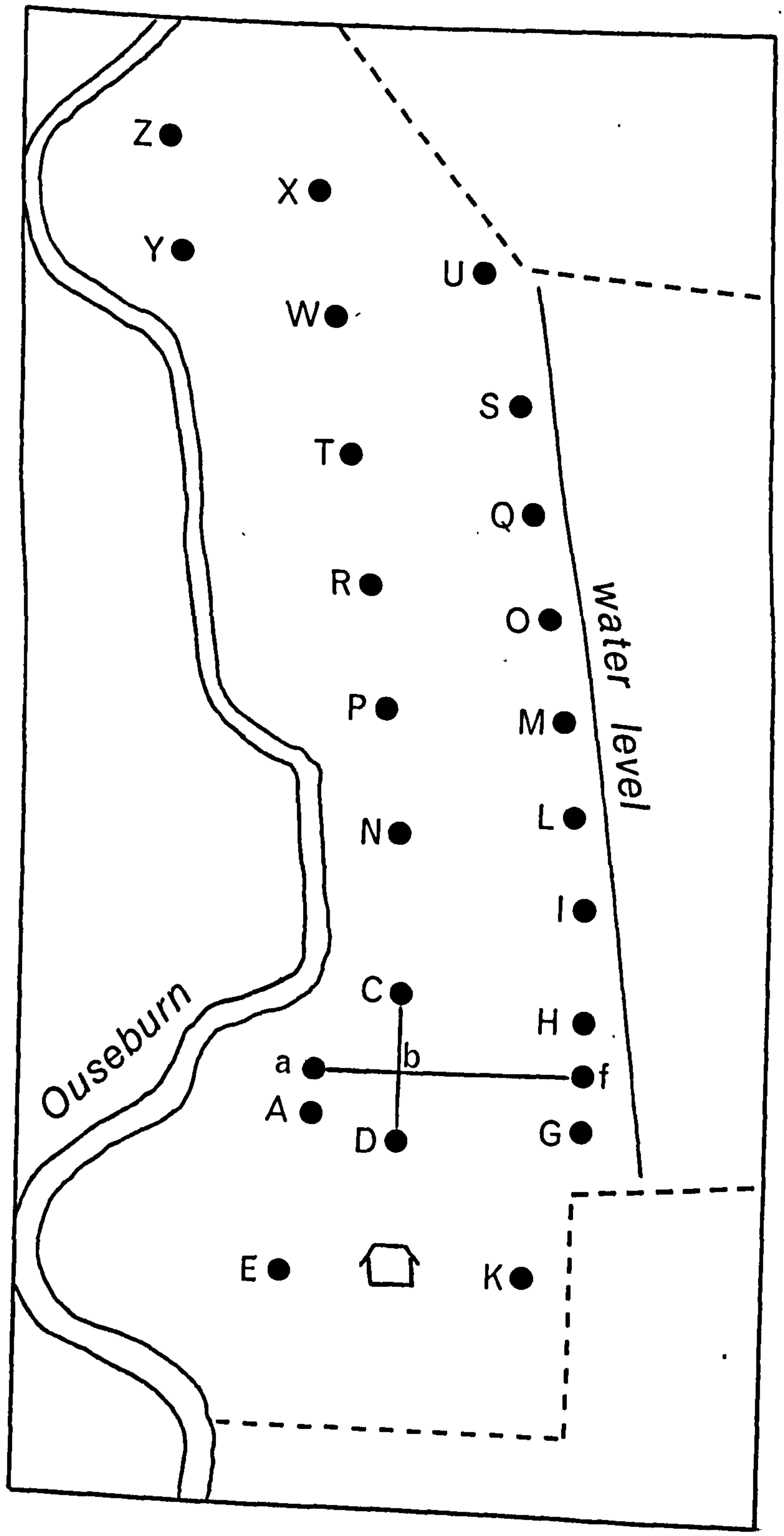
1. See Appendix C
2. No evidence has been discovered to indicate exactly when this line was built. It is difficult, therefore, to know whether it predates the Plessey and Cullercoats lines. However, it was almost certainly the first on the north bank of the Tyne. See NEIMME, T.E. Forster Coll., 49/4, p 1

The nature of the Kenton winning suggests the viewers carried out such feats of drainage in the knowledge that they would spawn a number of pits. They may even have planned the progression of workings. This was certainly the case half a century after the Kenton winning, in 1725, when Heaton Colliery was won. Fortunately the plan which was formulated for the winning survives and is reproduced here as Figure 33 . It is a remarkably comprehensive example of early industrial planning. The progress of winning and working is predicted in considerable detail. A production matrix for the orderly working of each of twenty-two pits over a period of eighteen years is formulated. The theory may have been logical and far-sighted but unfortunately the harsh realities of variable conditions underground thwarted so straightforward an approach. A new production matrix was constructed in 1736 and is shown here as Table 20 . By this time the colliery had been forced to harness four atmospheric engines whereas the initial plan had foreseen only one [1]. Nevertheless the colliery lasted about as long as was forecasted in 1725 and, if the drainage requirements were underestimated, this did not necessarily invalidate the methodological approach. Long-term planning, insofar as it was possible in so hazardous a business, had arrived to stay. The advent of boring more than anything else made it possible. Consequently a team of six viewers perused Longbenton in 1740, just before the first winning began and concluded

> ... that there will be 6 pitts at 3 pitts in a breast and there may be other 10 pitts at 2 pitts in a breast which will be in all 22 pitts [2].

Oddly enough this was the same number that was initially forecast

1. See pp 112-20
2. NEIMME, T.E. Forster Coll., 49/4, pp 53-5



Year	A	C	D	E	G	H	I	K	L	M	N	O	P	Q	R	S	T	U	W	X	Y	Z
1726	500																					
1727	200	100	100	500																		
1728		400	400	400																		
1729		400	400		400	400																
1730					400	400	400	400														
1731							400	400	400													
1732							200	200	400	400	400											
1733									100	400	450	400	450									
1734										100	150	400	450	400	450							
1735												100	100	400	450	400	450					
1736														100	100	400	450	400	450			
1737																100	100	400	450	450	450	
1738																		100	100	550	550	500
1739																		500	500	500	500	500
1740														500	500	500	500					500
1741									500	500	500	500	500									
1742				500	500	500	500	500														
1743	500	500	500																			
Totals	1200	1400	1400	1400	1300	1300	1500	1500	1400	1400	1500	1400	1500	1400	1500	1400	1500	1400	1500	1500	1500	1500

"The above calculation supposes ye colliery to begin winning 25th March, 1726.
And that ye whole coals will be wrought out in 13 years and ye walls in 5 years..."

Explanation of the map:

"a,A Two pits already sunk and ye coale taken up & drifted between, the northernmost of which must be sunk 7 fathoms to ye metal coal and drifted eastward 150 yards till it cut ye Maine Coale at b.

b. A water level drift to be run north and south 100 yards each way. Two pits should be sunk at C & D.

E A drift to be drove from A to E where a pit should be sunk west of Alderman Ridley's house.

f The drift to be continued from b. to f. 200 yards to ye dip where ye engine should be placed for winning ye colliery

N.B. If ye water be easy may perhaps get 50 yards further to ye dip to sink ye pitts f.G.H.

G,H Two pits to be sunk near ye engine for air and coal work."

Figure 33 : A plan for the winning and working of Heaton Colliery, 1726 (figures in tens)

TABLE 20 : Amos Barnes' and Richard Walton's plan to work the remaining coal out of various pits at Heaton Colliery, formulated 22 February, 1736 (figures in tens)

Year	Stock resting	Wheat	Plain	4th Engine	Thistle	Fortune (or First)	Corn	Whim	Meadow	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Total
1735	231																231
1736			600	580	580	150											1910
1737			520	520	520	400											1960
1738			480		100	400	240	520	520		240						2500
1739						50	400	260	480	520	400	150	150	150			2560
1740							400			480	400	400	400	500			2580
1741							400				400	400	400	500	400	500	3000
1742		300					360				360	400	400	500	400	500	3220
1743		500										400	400	150	400	500	2350
1744		500										50	50		400	300	1300
1745		500													200		700
Total	231	1800	1600	1100	1200	1000	1800	780	1000	1000	1800	1800	1800	1800	1800	1800	22311

Source: NEIMME, T.E. Forster Coll., 49/4, p 26 for Heaton.

However, after this the improvements of techniques of underground haulage, the search for deeper coal and the fact that the cost of sinking was not reduced by new technology meant that the number of pits which were sunk per colliery was steadily reduced. The total cost of sinking a pit at Gosforth estimated by John Watson in 1816 amounted to well over £3,000.[1] By that date it was accepted that most collieries could make do with one or two shafts. Yet Wallsend had required seven pits and Walker eleven or twelve in the period before 1800. This suggests that it was not until after 1800 that technological mastery of underground conditions was great enough to allow the exploitation of a whole royalty from a single surface site. Consequently, the density of sinkings shown by Figure 34 does not simply reflect the depth of coal from the surface. There is a greater density of pits in the Wallsend Basin than in the area to the north of the Ninety Fathom Dyke despite the fact that the coal was deeper there. This is the clearest indication that the spatial development of the coalfield does not reflect the simple interaction of physical conditions with a consistent, unchanging technological response. The geographical impact of coalmining in these two areas differed because the technological response was different.

7.7 The changing scope of technology

New technology did not only alter the pattern of coal working underground. There is considerable evidence to show that the changing scope of technology dictated the timing of winnings and that it was only after the introduction of new and better techniques that previously inaccessible deposits were brought within the ambit of economical working. Two eighteenth century examples may be cited here.

1. See Appendix D

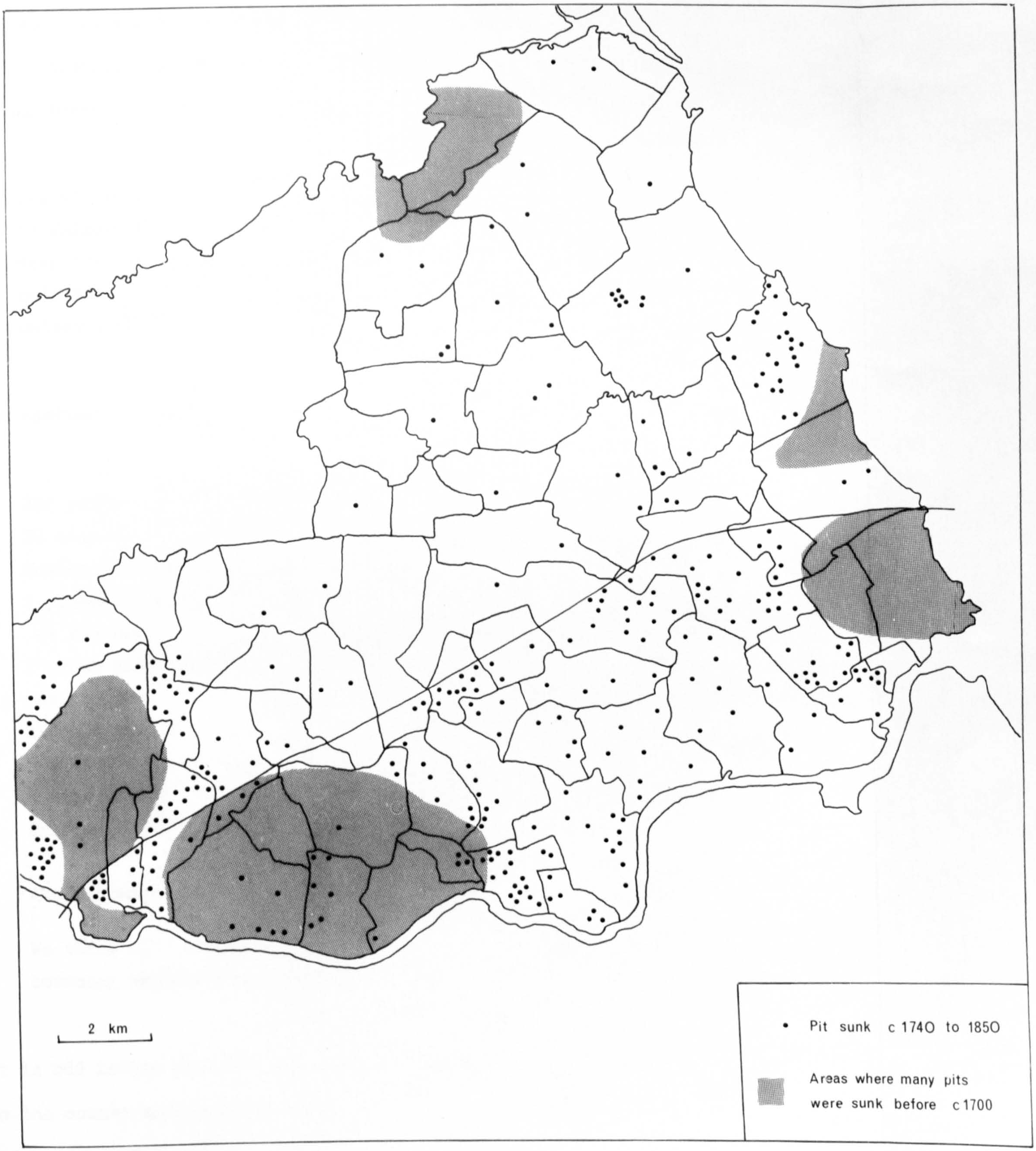


Figure 34 : The distribution of pits within the study area

By 1713 an ambitious scheme had been undertaken by Christopher Rutter and Hugh Bethall to win Walker Colliery by the normal 'pit and adit' method despite the fact that the coal in Walker was well beneath the normal level of winning at that time. In that year an estimate was made

> ... of the charge of bringing up a levell from Stot's Row to Walker Pits belonging to Hugh Beathell Esq. as also putting down the two present pits that's now sinking & two more for half lifts with sinking a coale pitt & building 3 coale or watter gins [1].

The costing included;

200 yards open cast & 1868 yards closed drift	£1213 - 10 - 0
20 staples	320 - 0 - 0
Rowles and ropes	25 - 0 - 0
2 present coal pits has 54 fas. each to sink at £15 per	1620 - 0 - 0
2 other pits each 47 fas. for half lifts at £10 per	940 - 0 - 0
A coale pit 73 fas. at £7 per	511 - 0 - 0
3 watter or coale gins	100 - 0 - 0
4 gins covers	136 - 0 - 0
Driving 40 yards of stone drift between pits	12 - 0 - 0
Whole charge	£5009 - 0 - 0

> We think upon second view there may be 9 or 10 pitts in Walker boundary which may cast 9000 tenns.

It is odd indeed that in the very year when the first atmospheric engine in the county was being erected in the adjacent royalty of Byker, this attempt should be made to win Walker. It is clear that the technique

1. NEIMME, shelf 18, Richard Peck's View Book, p 18

was of the normal 'pit and adit' type, but the scale of the undertaking - pits 73 fathoms deep and an adit over a mile in length - was exceptional. More significantly still, the project appears to have been a complete failure. There is no evidence that any coal was worked. Walker certainly did not appear in the list of collieries working in 1724 [1]. In 1738 George Claughton, commenting on the undertaking, said that "... she had not paid the expense ... I have seen several pits sunk to no purpose" [2]. The inevitable conclusion is that it was not possible (or perhaps economical) to win the High Main in Walker without the aid of steam pumping. It needed the advent of the atmospheric engine before Walker could be effectively drained. The colliery was thus beyond the scope of pre-1725 technology. Half a century elapsed before Walker was won and, even then, it took the most powerful engine in the coalfield to drain the pits [3].

An even more conclusive example of the changing scope of technology is provided by Heaton Colliery. In 1745 the colliery was succumbing to the rising of water unleashed by the cessation of pumping operations at neighbouring Jesmond [4]. The owners, anxious to avoid the complete demise of operations, investigated the possibility of making a separate winning in an adjacent area called the Spanish Closes. Nicholas Walton expressed the doubt felt by most of the viewers consulted at that time;

> it is not possible to win the seam of coale in the Spanish Closes aforesaid the same lying at so great depth ... and subject to fire in a much greater degree than that part of the colliery to the rise thereof ... it is impracticable by any power of fire engine or

1. See Table 6
2. NEIMME, Buddle Coll., vol 14, p 363
3. See pp 126-7
4. See pp 116-8

> other engine yet known to draw and carry off the water from the seame of coale lying under the said Spanish Closes [1].

In other words the existing technology was inadequate. The project was not undertaken. By 1786, however, the great improvements which had in the meantime occurred enabled George Johnson to view the position in a completely different light;

> the gentlemen who made the views at Heaton were unanimously of opinion that it was impossible to win and work the remaining part of the coal to profit. I grant that at that time it was very natural in them to infer from the quantity of water met with in Heaton and Longbenton Collieries that large or larger feeders would be found in winning the Spanish Closes where the depth was expected to be much greater but experience has convinced us that this does not always follow. For instance, Walker has much less water than either Longbenton or Heaton, altho' the pits are deeper and Willington at the depth of 121 fathoms has much less water than Walker ... with respect to the hazard of winning I think it no greater than what would probably attend one of the same depth as Walker; as to the working of the coal against the drowned wastes abovementioned, there is almost certainly a considerable risk, but no more than has attended the working of Byker against Heaton wastes [2].

This is a perfect example of the kind of re-appraisal which was constantly necessary in conditions of changing technology and new experience. In 1745 the viewers had laboured under one critical misconception; they believed that the reception of water by mineworkings increased with depth. By 1786 it had been realised that this was only true up to a point, and below that point conditions became drier. It

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1. NEIMME, Watson Coll., 10/43
2. Newcastle Central Library, Colliery MSS, vol D, pp 10-1

was not only the physical scope of technology which had increased during the intervening forty years but also man's accuracy of perception and technical confidence. The re-winning of Heaton was effected in the early 1790s [1]. The venture seemed to be a success and the colliery worked profitably for twenty years. But the insidious element of hazard, the ineradicable possibility of disaster, so intimately interwoven in the course of mining history, made its own harsh comment on man's efforts to psycho-analyse nature. In 1815 one of the exploring drifts at Heaton communicated with the drowned wastes of old Heaton and Jesmond Collieries, abandoned some seventy years before, and caused an innundation of water resulting in the loss of some seventy-five lives.

7.8 The diffusion of innovations

> In a free industrial system ... everything is a question of cost ... in coalmining we must descriminate (sic) the physical and commercial possibility. The second presupposes the first but does not follow from it [2].

W. Stanley Jevons' keen observation has profound implications for the development of the Northumberland coalfield. New techniques, like steam pumping and rail haulage, could greatly expand the sphere of technical possibility in mining. But this new area within which mining was technically feasible did not immediately spawn collieries across the whole of its extent. Instead, mining would begin tentatively in the location within the area where combined winning and working costs were minimal. The timing and location of extraction within the area of technical

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1. NEIMME, Watson Coll., 10/43
2. W.S. JEVONS, op. cit., pp 56-7

possibility was dictated by mining economics; that is, by the multitude of items of cost which determined total capital outlay [1]. Accepting these premises it is easy to understand that innovation adoption and diffusion was a painstakingly gradual process.

New technology was almost invariably expensive. The cost of winning Walker by the old 'pit and adit' method in 1713 was estimated at £5009. The cost of erecting a single atmospheric engine in the first half of the eighteenth century was normally £1200. Heaton needed four such engines and the total expenditure on that colliery was estimated at £30,000 [2]. New collieries employing the most up-to-date techniques and machinery needed to have a large output so that profit margins were substantial enough to eliminate the great deficit incurred by initial capital outlay. The cost of the Heaton winning was so great that Sir Henry Liddell "... was never reimbursed his share thereof with interest by his share of the profitts made in the severall succeeding years" [3]. So enormous was their winning cost that the deeper collieries of the Wallsend Basin, which had to adopt the most sophisticated techniques available, needed to sustain a much larger output than their shallower competitors [4]. Arguably, therefore, the regulation of the coal trade, by limiting the output of the larger collieries, may have inhibited the adoption of new techniques. The viewers were certainly well aware of the advantages of economies of scale. In 1787 the following estimate was made of the expense of working Walbottle Colliery,

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1. See Appendix D
2. NEIMME, Watson Coll., 10/43
3. See pp 116-8
4. Hence in 1804 the production of deep collieries like Wallsend, Walker, Willington, Percy Main and Heaton was far in excess of that of shallow collieries like Wylam, Walbottle, Murton and Kenton. See Table 9

accounting for two possible levels of production, one of 17,500 chaldrons per annum and the other of 12,000 chaldrons; [1]

	17,500	12,000
Engines	£800	£800
Gins and ropes	£100	£ 90
Waggonway and waggons	£460	£400
Staith expenses, agents, etc.	£120	£120
Agencies at colliery	£120	£120
Barroways underground	£150	£120
Staiths and wrights	£140	£120
Screening and wailing	£180	£150
Sledging and banking	£180	£130
	£2250	£2050

Thus if the output of the colliery was increased by 46 per cent, the working charges were expected to increase by a mere 10 per cent. And yet regulation militated strongly against economies of scale.

It has become clear that many of the most important innovations had their origins outside the region, and even the country. The spread of their use was usually a very gradual process. This is certainly true of both steam pumping engines and railway. The first atmospheric engines on Tyneside were erected between 1713 and 1716. And yet by 1738 only in the Ouseburn Valley had they been successfully adopted. The first waggonway was built by Beaumont at Bebside sometime betwen 1605 and 1608 and yet only one or two more had been erected half a century later. It appears that new techniques as radical as these needed a long period of incubation before their adoption was finally assured.

1. Newcastle Central Library, Colliery MSS, vol A, p 33

The slowness of early adoption is a facet of innovation diffusion which has not always been appreciated. Writers on the development of railways seem especially anxious to push back the date of inception. Some suggest that landowners in Northumberland and Durham were quick to realise the potential of wooden railways in the seventeenth century. If so, they saw it as a very limited potential. Considering the early date of the first, and their ultimate impact, surprisingly few waggonways were built before 1700. The first on the Wear was as late as 1693. Even M.J.T. Lewis seems anxious to postulate the existence of early lines. Thus he indicates one at Benwell in 1708 where, very probably, there was none [1]. Here he has failed to appreciate that at first the benefit accruing from railway construction was proportional to length of haul; and the coal-owners were keenly aware of cost-benefit utility. Collieries like Benwell with hauls of a few hundred yards could make do with carts and wains. Dunn states that even in 1726 Jesmond Colliery needed 700 wains to carry its coal to Ouseburn. In 1710 a waggonway had not yet been built between Whorlton Moor Colliery (Newbiggin)

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1. M.J.T. LEWIS, op. cit., 112-3. Lewis probably bases his assumption on a map of Benwell in 1708 which was copied by John Newton, surveyor, of Chancery Lane in 1785 (see NRO, ZSW/191-2). This map has a number of obscure symbols one of which could conceivably indicate permanent way. Personally I am extremely sceptical both for the reasons given in the text above and because pits in Benwell were very short-lived, a fact which demanded a flexible mode of transport. For all their shortcomings carts and wains were more flexible than waggonways. The plan from which Figure 14 was produced (see NEIMME, 42/47) indicates 'the old coal ways' and 'the new coal road'. Whether this change in nomenclature denotes the adoption of new technology or not is also debatable. It is very difficult to see what advantages could have accrued from so short a line.

and the Tyne although the haulage distance was twice that of Benwell [1]. But Kenton, very near to Whorlton, probably had one by this time, the difference being that Kenton was a much larger and more ambitious project. In 1738 John Millet said that waggonways were only used "... in collieries that lie distant from the Rivers, those that lie near the river have not occasion for them" [2]. He also states that at that time there were only 42 miles of permanent way and yet the aggregate distance of collieries from the Tyne was 185¾ miles [3] (although it sometimes occurred that more than one colliery used the same waggonway). Even if the adoption of waggonways had been increasing "... ever since the year 1722" [4] it seems unlikely that the process was completed until 1750, almost a century and a half after they first appeared. In pumping too there are many examples of anachronistic technology. Bebside Colliery, for instance, was drained "... by tubbs and horse-gins" as late as 1781 [5].

In detail the factors governing the adoption and acceptance of new techniques are extremely complicated but the assessment of cost-benefit presented by consultant viewers was of over-riding importance. The process by which viewers themselves became aware of new ideas and inventions was also intricate [6]. It is obvious, however, that they formed quite a closely knit fraternity and that ideas passed freely among them. It is also true that Tyneside viewers had contacts outside the North-East. Especially evocative is an entry in John Watson's journal, dated March 5th, 1750;

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1. NEIMME, shelf 18, Richard Peck's View Book, p 17.
2. See p 267
3. See Table 7
4. See p 267
5. Newcastle Central Library, Colliery MSS, vol G, pp 72-3
6. This is revealed by the relationship between Thomas Barnes and Boulton and Watt.

Rode to Prudhoe to Mark Wrights with a letter from Mr Newton. Rode from Prudhoe to Throckley Fell to Wm Brown's who has been at Whitehaven lately. Asked him some questions concerning that affair to which he answered as follows -

'They have square pillars for the support of ye roof, each pillar 13 yards square and the Board and Heads both alike in breadth viz. 4 yards; their Main Coal (or band as they there term it) is about 2½ or 3 yards high & is 115 fathoms deep - they are now sinking a pit he says will be 120 fathoms - in sinking they stop no water but put in rough bleeding fm. top to bottom which forces the water to keep the wall - they draw their water with fire engines. The head viewer's name is Carlisle Spedding to whom (I) was introduced by a Gent'.[1].

Spedding, inventor of the 'steel mill', was to become renowned in his own right, while Brown and Watson later became the most eminent Tyneside viewers of their day.

7.9 The diversity of winning technique

The methods by which individual collieries were won were extremely varied and changing technology alone does not explain this variety[2]. The diversity of physical conditions also played a key role, as did the human geography of the coalfield surface. The interaction of these basic factors determined the geography of winning and coal extraction at the local level. It is therefore worth examining some examples of individual winnings. Four have been chosen. Since they were all planned between 1805 and 1817 it is unlikely that differences between them were the result of changes in technology. The winning of Coxlodge Colliery and of Gosforth Colliery are interesting because they are broadly analogous and are discussed here comparatively. The Byker project of 1814 is an example of a small-scale undertaking with very limited aims. And the re-winning

1. NEIMME, Watson Coll., 8/4, p 164
2. Figure 35 is an example of a mid-eighteenth century winning.

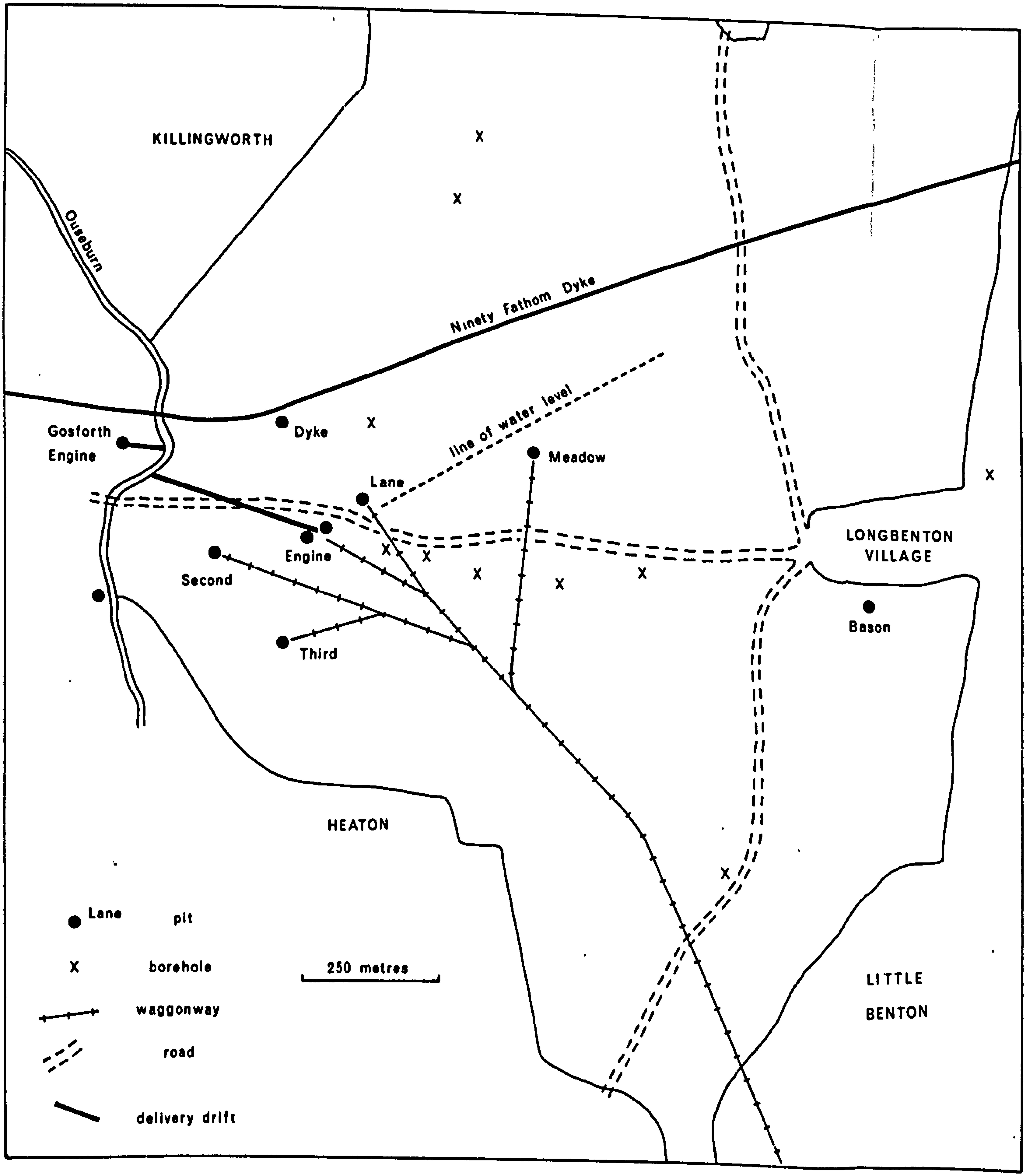

Figure 35 : Longbenton Colliery in 1749

of Walker in 1817 took place after it had been drowned a few years earlier.

The royalties of Coxlodge and Gosforth were very similarly situated. Both lay astride the 'Ninety Fathom Dyke' but mainly to the north of it. In both cases access to the Tyne was obstructed by the built-up area of Newcastle and full exploitation had to await improvements in surface haulage as well as better winning technology. The place of both within the centripetal movement of operations north of the dyke has already been explained [1]. The nature of that movement dictated that Coxlodge was the first of the two to become viable. The colliery was procured by the proprietors of neighbouring East Kenton and was, to some extent, an extension of that colliery. The Gosforth winning, on the other hand, was entirely discrete. As an extension of East Kenton Coxlodge could be won much more cheaply. In 1808 an estimate of the cost amounted to £18,000. It included the following items; [2]

Sinking a 12½ feet diameter pit 115 fathoms	£3005
Driving stone drift to cut the seam north of the dyke	£1215
Two machine engines for drawing coal	£2500
Shifting Main Engine from Kenton to Coxlodge	£1000
Laying 5½ miles of metal plateway	£5808
Building 40 chaldron waggons	£ 960
Erecting 6 houses, smith's shop, etc.	£ 920
20 waggon horses	£ 520
Staith and spout	£ 593

The cost of the Coxlodge winning was only half that of the Gosforth project. There were a number of important differences. The main

1. See pp 165-6
2. NEIMME, Watson Coll., 9/13

pumping engine was to be transferred from Kenton to Coxlodge at a cost of £1,000. But Gosforth needed to obtain a brand new engine, priced at £5,500 [1]. The opening of Gosforth necessitated the recruitment of a labour force, and housing the families in a new pit village was expected to cost £8,400. Providing a workforce for Coxlodge merely involved the redeployment of workers from Kenton where operations were being cut back. Most of the workers would already be housed locally and a minimum of new construction would be necessary. Thus considerable benefits accrued to Coxlodge from its link with Kenton, benefits which were not enjoyed by Gosforth. On the other hand Coxlodge, because it was won first, had to construct a 5½ mile metal waggonway to Bigge's Main at an estimated cost of £5,808. Later, Gosforth was able to use this link for transporting its own coal, reducing the cost of building permanent way to less than £2,000.

Another, geographically more significant connection between Gosforth and Coxlodge concerned the location of the respective pitheads. In 1807 there were two possible methods for winning Coxlodge. First, by placing the new engine pit "... on the extended line of the outstroke water level drift from Kenton" [2]. This involved simply moving the engine at Kenton eastwards to a new pit in Coxlodge located in a position which corresponded closely to that of the old Kenton Engine Pit [3]. This was the simplest method for making a winning in Coxlodge but would, in fact, drain only half of the coal in the royalty. The second, more ambitious method comprised the sinking of pits on the south side of the Ninety Fathom Dyke and the driving of long drifts through the fault-line to cut the High Main on the north side. John Buddle described this method

1. See Appendix D
2. NEIMME, Watson Coll., 9/13
3. See Figure 36

as " ...unquestionably to my mind the most eligible". He emphasised the disadvantages of the first method;

> 1st. The expence (sic) of this method will be fully as much I conceive as an effectual winning made to the full dip of the Colliery, including the expence of drifting, boring and c.
> 2nd. Being so placed as to leave a large tract to the dip unwon, the coal so left cannot be wrought, but at a very increased expence; which invariably attends the working of collieries so situated, arising from a variety of obscure causes [1]

Two other important advantages were expected to accrue from the second method;

> The probability of getting down without being incommoded with more water than a thirty-horse machine will draw ...
> That it will win the Low Main and seams above and below.

The balance of advantages seemed to weigh heavily in favour of the more radical winning on the south side of the Ninety Fathom Dyke. Such a winning would drain over 300 acres more coal, would enable an exploration of the seams below the High Main, would be no more expensive and would meet with less water. However, these latter two alleged advantages were open to doubt. Thomas King was certainly sceptical of the last;

> If the chief cause of making the complete winning of the High Main Coal in Coxlodge on the south side of the Great Dyke is that of effecting it without getting much water, nothing appears more probable than the contrary will happen, as that Fluid is met with generally at all depths below the surface and that of 70

1. NEIMME, Watson Coll., 9/13

> faths. I believe winnings have been made between the High and Low Main Coals and little water met with but it always happened where those seams lay at a greater depth under the surface [1].

Knowsley and Chapman, then majority owners of Kenton and Coxlodge, opted for the safer alternative; a winning

> ... by driving two water level drifts from the present pit in Kenton Grounds which drift is now drove 920 yards ... and will have to be continued 380 yards further to the intended new pit in Coxlodge ... The situation of this pit is water level from the present Engine level, it will win the coal above that level which is estimated to contain 454 acres of Coxlodge Estate [2].

The new pit in Coxlodge was called the Jubilee. Its position, and that of the colliery generally, are shown on Figure 36.

The problems which Kenton and Coxlodge Collieries encountered after this time have already been discussed at some length [3]. They arose from a number of causes and the extent to which they can be attributed to the location and nature of the winning is debatable. The profits from the colliery were described at one point as "trifling", however, and this was a result of the combination of high working and haulage costs. Moreover, the rationale behind the later winning at Gosforth throws further light, from a position of hindsight, on the decisions made at Coxlodge.

When Thomas King, estate agent for the Brandlings, owners of Gosforth,

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1. NRO, Ridley Coll., ZRI/35/22, pp 156-60
2. NEIMME, Watson Coll., 9/13
3. See pp 167-74

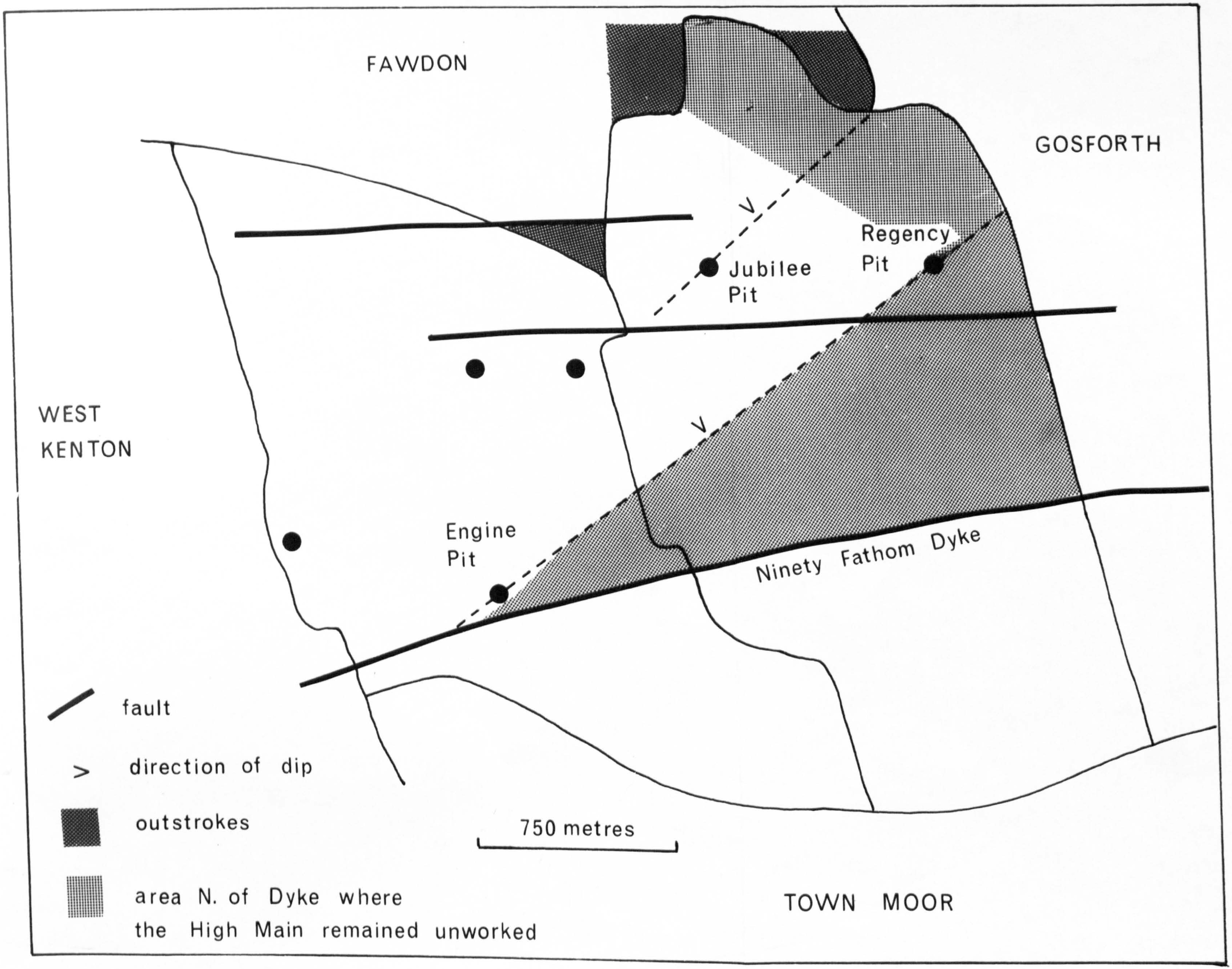

Figure 36 : Coxlodge and Kenton Colliery in 1807

offered wayleave for the waggonway from Coxlodge, with considerable prescience, he stipulated that

> ... should the lessor win and work Gosforth Colliery either on the North or South sides of the Great Dyke ... he or his lessees to have full power to lead and convey the coals produced by the said Gosforth Colliery along the Coxlodge waggonway ... on paying to the lessees of Coxlodge the sum of nine pence per ten per mile p. annum [1].

Thus while the owners of Coxlodge bore the enormous expense of constructing and maintaining the waggonway the owners of Gosforth had the use of it for a stipulated, inflation-proof charge. With regard to the precise location of the pithead the same dilemmas Coxlodge had faced arose at Gosforth;

> the question as to the most adviseable (sic) situation for the winning ... whether on the north or south side of the Dyke.

But now, as far as John Watson was concerned

> ... it does not ... admit to a doubt to which side the preference ought to be given, as it appears evident to me that sinking the pit on the south side of the Dyke and drifting through the same 'till it cuts the coal on the north side as suggested by you is the most eligible mode that can be adopted [2].

What is more significant is that it was partly the experience of Coxlodge which enabled the choice to be made with such certainty. This time Watson was able to assert confidently that

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1. NEIMME, Watson Coll., 9/13
2. NRO, Ridley Coll., ZRI/35/22, pp 156-60

> ... it has been frequently proved that there is (sic) no feeders of water of any consequence met with below the High Main Coal seam on the south side of the Main Dyke, while on the other hand it is very much to be apprehended ... that the same feeders of water will have to be contended with in sinking, as was met with in the adjoining collieries of Killingworth and Coxlodge which are put down on the north side of the said downcast Dyke [1].

The sinking of the Gosforth engine pit on the south side of the Ninety Fathom Dyke began in 1824. The lesson of Coxlodge had been well learned.

The operations which took place at Byker during the first two decades of the nineteenth century are in stark contrast to the great new winnings of extensive, unworked royalties like Coxlodge and Gosforth. By the end of the eighteenth century the area around the Ouseburn, immediately east of Newcastle, had been already exploited by a series of independent piecemeal winnings. However, an extensive barrier of coal had been left along the west bank of the Ouseburn to separate old Heaton and Byker Collieries from the uncharted medieval workings in Shieldfield and along the east walls of the city. Furthermore, by the nineteenth century the remaining areas of High Main were limited in extent and the Red Lane or Red Barnes Barrier excited the attention of a number of adventurers. The shallowness of the coal and proximity to the Tyne suggested that a winning could be affected fairly cheaply. Moreover, barriers of the extent of the Red Barnes contained large quantities of coal and, if such a winning of the High Main could be combined with a more extensive attack on one of the lower, unworked seams in Byker a viable colliery might thus be sustained. The Low Main

1. NRO, Ridley Coll., ZRI/35/22, pp 156-60

seam in Byker had already been worked by outstroke from the Delight Pit in Walker but the owners had

> ... not been able to work it to profit, they relinquished the undertaking, the colliery was again abandoned and the Delight Pit was filled up [1].

After this William Chapman and co.

> ... took it with a view it is said to work the Red Lane Barrier, ... but afterwards having reason to believe they were mistaken in the position of the barrier and being discouraged by the general prospects of the concern they abandoned the enterprise.

Later still, Harrison Cook and co. undertook the same enterprise. They reopened the Delight Pit and forced a passage through the 'crept' High Main Seam to the Red Lane Barrier.

> They hoped to be able to work this Barrier together with any remaining Pillars ... in the ancient drowned waste to the westward of the Red Lane Barrier by letting off the water through it into Ald. Ridley's old workings from whence they expected it would find its way into Walker Colliery. In this, however, they were mistaken as the water did not find a passage through into Walker Colliery and they were obliged to plug up the holes to avoid being drowned out of the Delight Pit [2].

The company became bankrupt and the project was abandoned in about 1810 [3]. For a time subsequently a few small tracts of Byker coal which were still

1. NEIMME, Buddle Coll., vol 14, p 24; vol 6, pp 87-95
2. NEIMME, Buddle Coll., vol 6, pp 88-90
3. NEIMME, Buddle Coll., vol 3, p 158

intact were worked from Heaton. In 1814, however, a more determined attempt was made by Straker and Taylor to win the Red Lane Barrier with an independent engine pit. Figure 37 shows the plan for the winning. Any possibility that this small project might have flowered into a major colliery was thwarted by the inability of Straker and Taylor to obtain outstroke leases for enough areas of Byker. The reason for this reflects the increasing degree of strategy and foresight with which the industry was now planned. Unfortunately the most eligible area for working from their new winning was also "... a complete key to the corporation coal, and that of Sir Matthew White Ridley, as well as to the Birdnest and St. Anthony's" [1]. These were all fairly small areas of unworked or partially worked coal. Buddle recommended to Sir Henry Lawson that the Byker royalty be "reserved" so that it could be let in conjunction with other adjacent royalties, "... all the royalties together will form the proper extent of a colliery in the lower seams" [2].
Consequently Straker and Taylor were prevented from extending the scope of their enterprise because it did not fit into Buddle's masterplan.

Only a mile or two away at Walker a decision had been made in 1810 to lay in the colliery temporarily. It was estimated that the remaining pillars in the High Main Seam would yield a further 40,000 chaldrons, enough to sustain the colliery for a further sixteen months. By this time, however, it was well understood that the High Main would not last forever and, sooner or later, its progressive exhaustion throughout the coalfield would mean that the working of inferior seams below it would become an economic proposition. The viewers at Walker

1. NEIMME, Buddle Coll., vol 6, pp 87-95
2. Ibid.

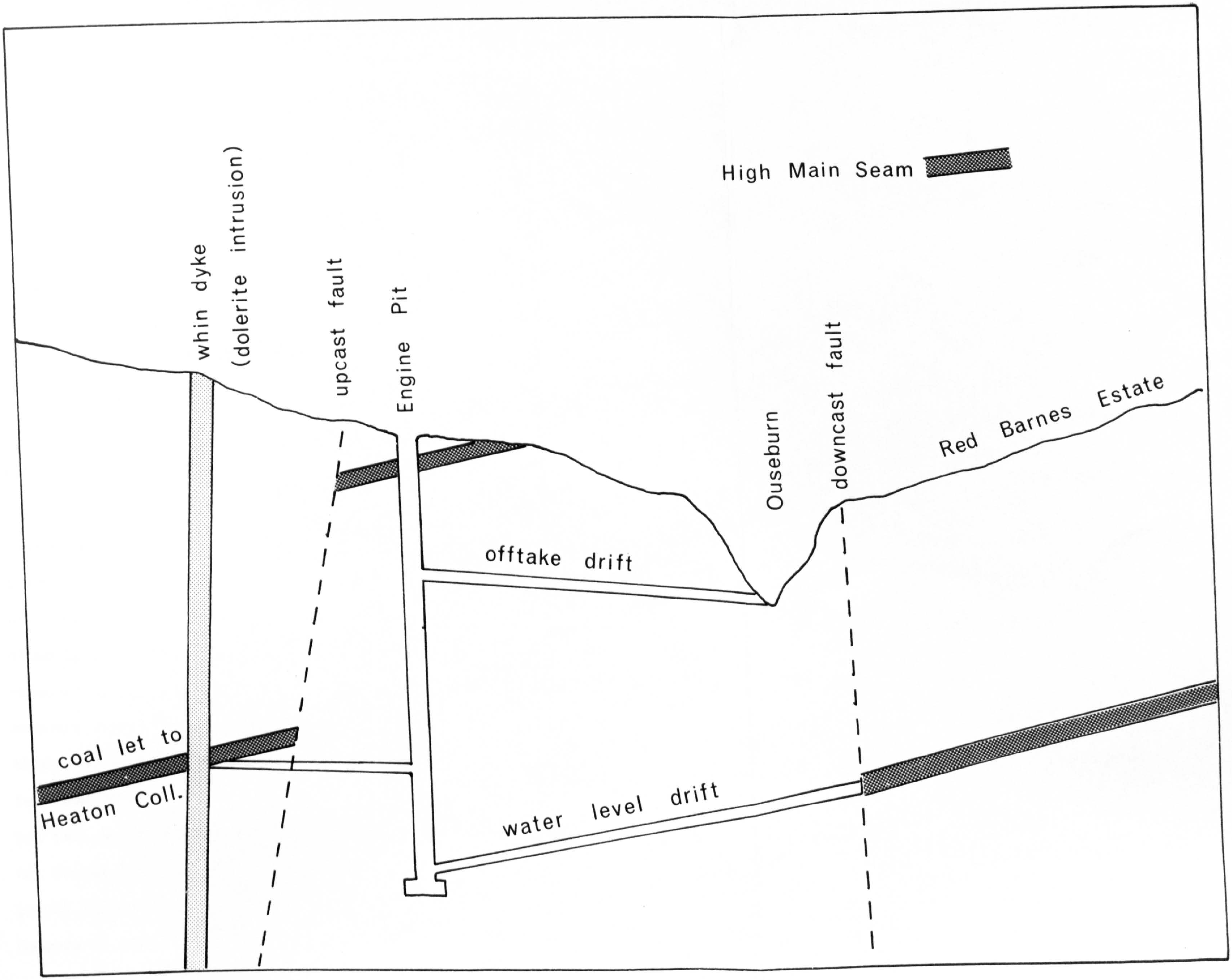

Figure 37 : The Red Barnes winning, Byker, in 1814

> ... Being of the opinion that the Low Main and some of the other seams below the High Main will at no very distant period become a source of revenue ... we recommend that access should be preserved to those seams by effectually tubbing the Charlotte and Jane Pit shafts thro' the waste of the High Main Coal Seam ... Previous to fixing the tubbing we recommend the two pits ... should be secured by pillaring and stowing the workings immediately adjoining the same to a distance of 80 yards in every direction ... the expence of effecting the whole which we estimate at £6000 [1].

In other words rather than abandoning the colliery completely the lessors of Walker were to take steps to preserve the pits as re-usable units of production. In fact the colliery was dormant for only six years or so. In 1817 a scheme was undertaken by John Carr and co. to re-open the colliery with a view to both clearing out some remaining areas of High Main pillars and commencing the exploitation of the Low Main.
James Jobling and Thomas King estimated that the total cost of the project would amount to £22,000 and the colliery thus won would supply a vend of 30,000 chaldrons for 25 years. The advantages of a process or re-winning, as opposed to the colonisation of a virgin royalty, were clear in the accounting. 'Ridding' the Gosforth and Henry Pits was expected to cost only £300 [2]. To have sunk two such pits, starting from scratch, would have cost about £3,000 and taken a number of years. But there were also disadvantages in re-winning not normally encountered in tackling whole coal. At Walker, for instance, the pattern of drainage had been so affected by 'creeps' and 'thrusts', the effects of subsidence during the period that the colliery was closed, that re-draining proved extremely problematical. Without free passage of water the dangers of sudden innundation during working were obviously increased.

1. NEIMME, Watson Coll., 13/103
2. NRO, Ridley Coll., ZRI/35/22, p 179

In 1818 a rather perverse situation had been reached whereby the pits were 'ridded' and the new pumping engines erected but there was not enough water at the bottom of the shafts for them to lift. But the problems of the enterprise were more complex, as John Straker observed;

> It appears to me very forcibly that in the first outset they have formed the most erroneous judgement of the state of the coal left by the former lessees; to propose a sum of 30/- a ten for the fragments of coal that have been previously crept and saturated with water is to say the least without a precedent in the coal trade; the mine rent is in my humble opinion full double the sum that they ought to have given if they had acted for themselves with common prudence [1].

John Carr and co. were forced to petition the Corporation of Newcastle, the lessors of Walker, for a reduction of rent. The reasons they gave were;

> the ruinous state of the coal trade ...the derangement of the said colliery in consequence of former creeps ...the bruised and inferior state of the coal ...the great quantity of water which has accumulated in the colliery ...the great loss by screening ... the great capital which has already been absorbed (a sum considerably more than double the estimate which was the guide for your petitioners) [2].

The petition was granted and, after a few difficult years, the colliery succeeded.

In comparing these winnings of Coxlodge, Gosforth, Byker and Walker the

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1. NEIMME, Watson Coll., 13/104
2. Ibid.

overall impression is one of diversity. The aims of the projects, the scope of the winnings, the engineering methods adopted and the factors influencing the location of pits and workings show great heterogeneity. Yet these operations were carried out in the same technological climate. Their diversity does not derive from technological change nor from great differences in the depth of workings. Geography seeks ultimately to make generalisations about spatial development. Perhaps the most important generalisation to be made about the development of the Northumberland Coalfield is that it varied enormously in time and space.

7.10 Capital investment and returns

The adoption of new technology and the increased scale of operations which accompanied it inevitably caused a rise in the level of capital investment in the coal industry. The organisational background to these developments - the dominance of the Company of Hostmen and later of the Grand Alliance, the rise to prominence of new partnerships like Bells and Brown in the second half of the eighteenth century, the role of owners, lessees and viewers - has already been discussed at some length but it is worth examining briefly the role of capital per se for finance was the vital lubricant of industrialisation the abundance or dearth of which could promote or retard progress.

The colliery was the same as any other commercial enterprise in that its viability depended on whether its turnover yielded a margin of profit. It seems, however, that from a relatively early date the nature of mining favoured the large-scale enterprise. This was because, except for the most superficial of workings, the initial capital input was substantial. It would be a myth to suppose that, even by 1600, a large coal-producing enterprise could grow from small beginnings, a few men hacking away at an outcrop. The cost of royalty and wayleave rents alone presupposed substantial initial capital investment, except perhaps for landsale pits which were sometimes very small. Above all, however, it was the cost of winning which excluded all but the substantial capitalist. Table 21 gives some examples of the cost of winning from the early eighteenth to the early nineteenth centuries, with the main contributing items of expenditure included. Although it is difficult to make comparisons (since the technical nature and scale in winnings was extremely varied) it is evident that winning costs escalated steadily throughout the eighteenth century mainly because of deeper mines and the cost of new drainage and transportation technology. Moreover such estimates usually turned out to be underestimated by a substantial margin as the viewers who formulated them readily admitted.

As early as the first decade of the seventeenth century Huntingdon Beaumont seems to have expended as much as £20,000 at Bebside [1]. Roger North said that in the second half of that century coal-owners often needed to spend five or six thousand pounds on drainage adits. North also mentions the abortive drift driven by Sir William Blackett at a cost of £20,000 [2]. The winning of Heaton Colliery from 1726 is supposed to have cost over £30,000. In 1796 John Watson observed of the Wallsend Basin that

> The expenses of winning collieries in this tract of country have been extremely different and are so much objects of mere conjecture that no estimate can be formed with any degree of certainty. Perhaps each of them may be stated at £30,000 [3].

1. See p 251
2. See p 275
3. NEIMME, Watson Coll., 13/110

TABLE 21 : Some viewers' estimates of winning costs, 1713 to 1826

			Total cost (£s)
1713	Walker	First winning. Incl. 200 yards open-cast & 1868 yds. closed drift (£1213), 2 pits 54 faths. each (£1620), 2 pits 47 faths.each (£940), one pit 73 faths. (£511), 3 gins (£100).	5,009
1714	Throckley	New winning. Incl.driving 700 yds, drift (£466), 20 workmen's houses (£200), staith (£175), 3 coal gins (£110) and 3 pits 14 faths. (£42)	1,355
1725	West Hartford	First winning. Incl.construction of dam (£82) and two 'bob gins' (£260).	500
1727	Chirton	First winning. Incl.two pits and a drift (£760)	1,503
1734	Byker	Extension of existing winning. Incl.pit 40 faths.(£312) and 'fire engine'(£849).	?
1740	Elswick	Re-winning. Incl.two 'fire engines' (£2000).	2,300
1740	Longbenton	First winning. Incl.pit 70 faths.(£800), another shaft (£500), 3 'fire engines' (£3600),and 5000 yds.waggonway (£1500).	6,820
1745	Heaton	Extension of existing winning. Incl. a pit 90 faths.(£3805), 2 engines (£2100), 2 coal gins (£2000), 2 miles of waggonway and a staith (£1560).	17,083
1760	Hartley	Extension of existing winning. Incl. 'fire engine' (£1500), drift 800 yds.(£1064) and pit 70 faths.(£340).	3,430
1803	Willington	New winning. Incl.main engine (£4500), two 'machines' (£3000), pit 125 faths., (£2500) and branch waggonway (£480).	13,200
1808	Coxlodge	New winning. Incl.laying cast-iron waggonway 5½ miles(£5808), pit 115 faths. (£3005), 2 'machines' (£2500), a drift 270 yds.(£1215), shifting main engine from Kenton to Coxlodge (£1000), 40 waggons (£960)and 20 waggon horses (£520).	18,000
1815	Wallsend	New winning. Incl.main engine (£4500), two 'machines' (£3000) and pit 125 faths (£2500).	13,200
1816	Gosforth	(see Appendix D)	36,211
1817	Walker	Re-winning. Incl.main engine (£5400), 2 machines (£3400), 2 miles of waggonway (£2400), 60 horses (£1500) and a staith (£1000).	22,000
1826	Seghill	First winning.	32,000

The small-time operator thus found it difficult to make an impact, at least during the period under consideration here. But the men of real talent, like William Brown, John Watson, John Buddle and, of course, George Stephenson, usually 'made it' in the end, perhaps renting a landsale pit at first and then, with some capital accumulated, entering a partnership. Nevertheless the financing of colliery operations was dominated by the gentry, although by the nineteenth century a large proportion of these were nouveau riche. In 1828 John Buddle estimated that the capital investment in the twenty working collieries between the Tyne and the Blyth amounted to almost exactly one million pounds, varying from £14,000 in Whitley, the smallest, to £120,000 in Killingworth [1]. Appendix D reproduces an estimate by John Watson of the cost of winning Gosforth Colliery in 1816.

The flow of capital into the industry from other areas of economic activity such as agriculture and manufacturing, within the industry, and from the industry elsewhere comprises a subject in its own right, and one so large and complex that it is impossible to justify its inclusion here. Since the existence and persistence of a profit margin was the ultimate determinant of viability, however, it is worth briefly considering the role of profits.

The coal-owners and their associates were notoriously reluctant, on the one hand, to divulge the extent of their profit from coalmining and mindful, on the other, to emphasise the risks and hazards of their business. Although the latter were undoubtedly considerable there can be little doubt that huge profits did accrue. Evidence of the extent of these profits survives through the activities of the viewers. When a viewer estimated the cost of winning and working a colliery he was

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1. See Table 12

normally also requested to assess the margin of profit which might be expected from it. For example, in 1760 Amos Barnes estimated that it would cost £5 - 15 - 6 to work and lead one ten of coal from Shiremoor Colliery, that the profit on each ten of eighteen chaldron would be £5 - 0 - 6 and that a yearly production of 1200 tens could be sustained for at least 8 years, yielding £50,400 [1]. However, working costs and the price of coal were variable so that such estimates were unreliable, although some attempted to budget for such variations. An estimate of the profit to be expected from Willington Colliery in 1822 is an example: [2]

Total expenditure on colliery and farm;	£51,909
Deduct profits from farm produce;	£ 4,225
Expense of working 36,000 chaldrons	£45,632
48,000 chaldrons increased vend will require additional expense;	£ 7,539
48,000 sold at following prices;	
43,500 chaldrons best coal 30/- per chald.	£65,250
4,500 chaldrons Forrest Main 18/- per chald.	£ 4,050
Profit;£13,327	
If coal sells at reduced price of 28/- and 17/-;	
Profit; £8,752	
If coal sells at reduced price of 26/- and 16/-;	
Profit; £4,177	

Table 3 , showing the profit from Benwell Colliery between 1709, when it was a fairly healthy concern vending almost 17,000 chaldrons, and 1722, when it closed down, reveals considerable variations. The profits of the lessees of the same colliery in the four years 1810 to 1814 were £4,828, £7,267, £4,897 and £5,567, suggesting that even ninety years

1. NEIMME, T.E. Forster Coll., 49/4, p 199
2. NEIMME, Watson Coll., 13/111

later the flow of profit was not much steadier [1]. Nevertheless this represents a substantial margin of return on investment. A valuation of Kenton and Coxlodge Collieries was made in 1811, when the concern was but three years old, and an annual profit of £10,000 was predicted for a duration of 22 years [2]. But coalmining remained a risky business. John Watson, one of the greatest eighteenth century viewers, died bankrupt, while John Buddle, one of his colleagues, reputedly left £150,000 [3].

7.11 Labour

The coalminer is an older occupation than is often supposed. It is difficult to determine exactly when the miner became a purely industrial worker. Even in the twentieth century the coalminer was traditionally a keen allotment gardener as well as a worker underground. The pit dwellings which were built early in the nineteenth century had large gardens attached to them as a matter of course. Presumably the first men to venture underground in search of coal in Northumberland were primarily farmers, the leaseholders of those manors - Benwell, Elswick, Hartley, Jesmond, Tynemouth - where mining began early in the middle ages. Yet by the beginning of the period under consideration here there were certainly specialised industrial workers who had ceased to be husbandmen. For example, the parish registers of Earsdon state that Robert Hutchinson, who died on the 4th June 1596 was the son of a 'collier', and Robert Gofton, who died in the same year was a 'banckman' [4]. Thus not only did specialised colliery workers exist by the late sixteenth century but there was also a division of colliery labour.

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1. NEIMME, Watson Coll., 9/3
2. NRO, Ridley Coll., ZRI/35/22, p 86
3. F.S. HEWITT, op. cit., p 3
4. NRO, Parish Registers, Earsdon, 3.

Furthermore, the Hearth Tax Assessment of 1676 indicates that a concentration of colliery labour had occurred in certain localities by then. For instance, as well as the 41 householders named in Benwell there were "28 poore colyors more" [1]. In Kenton there were "50 colyors more". In Newburn there were 71 householders classed as poor, a larger number than in any other parish in the county. Such evidence suggests strongly that by the middle of the seventeenth century the possibilities of employment in coalmining were leading to a concentration of the labouring poor in the coal-producing manors. In 1662 some 2000 pitmen are said to have assembled on Newcastle Town Moor to sign a petition to the king for the redress of their grievances [2]. But there is a perplexing lack of information about the ordinary pitmen of the seventeenth century. Early colliery leases indicate that lessees sought permission to build "houses, lodges, shedds and hovells" for the accommodation of workmen. A computation of the cost of winning Throckley Colliery in 1714 includes the cost of twenty workmen's houses at £10 each [3]. A century later John Watson budgeted for 140 workmen's houses at £60 each for Gosforth Colliery [4]. It seems that where new collieries were opened distant from pre-existing concentrations of industrial labour, mine-owners were forced to foot the cost of accommodating workers. There is strong evidence that pitmen also lived in existing villages, at first perhaps squatting on the village green (as in the case of Benwell) or crowding into houses which had been bought by the colliery. Figure 38 is based on a map of Newburn in the early nineteenth century and shows that much of the property in the village had been acquired by the colliery. There were also buildings called 'lodges' constructed near to the pits which presumably acted as

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1. PRO, E 179/158/106
2. M. ARCHER, op. cit., pp 132-3
3. NEIMME, shelf 18, Richard Peck's View Book, pp 21-6; 49/5, p 22
4. See Appendix D

Figure 38 : The village of Newburn in 1816

hostels for single men or teams of sinkers or borers temporarily resident there.

It would be possible to speculate at length about the working conditions, wages, living standards and mores of the pitmen but it is not the purpose of this thesis to do so. Labour is considered here only insofar as it is relevant to the geography of coalmining. Unfortunately it is not until the nineteenth century that useful data appears concerning the labour forces of individual collieries. The growth of the industry from 1760 onwards precipitated a great labour shortage which enabled the pitmen to raise their living standards appreciably in the later eighteenth century. The shortage of labour compelled the coal-owners to regulate, not only the amount of coal which each colliery could produce but also the number of workers which each could bind. In 1805 the coal-owners ended the competition for labour among themselves which had placed the pitmen in a better bargaining position. They resolved

> ... That the binding shall take place at each respective colliery office and nowhere else on any pretence and that no eat or drink shall be given directly or indirectly except the usual allowance of liquor ... That no person whatsoever be sent from one colliery to another to tamper with or hire the men of such other collieries and that no colliery shall be at liberty to hire more than ten men and twelve boys from any one of the present collieries. That Killingworth new colliery shall not bind more than one hundred men and a proportionate number of boys ... That there be no advance upon the rates and prices for hewing, putting and driving ... beyond the rates of last year [1].

These resolutions ushered in a period of unrest culminating in the destructive strike of 1832. Table 22 shows the apportionment of hewers

1. NRO, Coalmining Records, List B, vol I.

TABLE 22 : The apportionment of hewers to Northumberland collieries, 1802-12

Colliery	1802-4 (av.)	1805	1807	1809	1811	1812
Baker's Main	58	55	55			
Bigge's Main	82	77	69	49		
Benton	104	62	68	71	77	
Benwell	71	67	57	73	80	59
Backworth					45	40
Collingwood Main				62	76	82
Cowpen	95	95	84	91	90(?)	94
Cullercoats					12	40
East Kenton	62	52	70	101	105	135
Elswick	50	43	29	44	45	40
Flatworth	44	40	52	49		
Hartley	116	103	93	83	86	88
Heaton	101	93	88	64	82	73
Killingworth	100	69	96	76	74	98
Montague Main	45	40	26	39	49	49
Murton	70	45	68	76	77	70
Percy Main	117	105	92	122	123	141
Plessey	90	69	75	70	80	76
Walker	106	90	116	65	48	
Wallsend	123	114	97	106	115	117
West Kenton	not working	32				101(Fawdon)
Walbottle	127	106	96	124	106	110
Willington	108	89	95	108	130	135
Total	1,669	1,446	1,426	1,473	1,500	1,548

Source: NRO, Coalmining Records, list B, vol I.

to Northumberland collieries between 1802 and 1812. Figures 39 and 40 show the changing pattern of labour deployment which went hand in hand with the colonisation of the area north of the Ninety Fathom Dyke.

It is also possible to ~~gleen~~ some indication of variations in labour glean productivity. Where data exist~~s~~ for both the output of, and the number of hewers bound by, each colliery it is possible to calculate the average number of chaldrons worked by a hewer in a year. Figure 41 is a cartographic representation of such calculation for 1806. Predictably it shows that the larger deeper collieries working the High Main had a higher labour productivity than the smaller, peripheral outcrop collieries.

It is possible to explore this theme further. The ratio of hewers to total underground workforce may also be taken as an index of efficiency and productivity since hewers were the only workers employed in direct coal-working. Other underground workers were primarily concerned with the movement of coal underground or the maintenance of the mine. It follows that older winnings, where the coal faces had proceeded far from the shaft bottom, would require more non-hewers underground than the newer pits and would therefore have higher working costs. In this correlation, however, the depth of the seam below the surface is also a factor. Shallow collieries could afford to sink more pits and reduce the haulage distances underground.

Table 24 lists the collieries working between the Tyne and the Blyth in 1844 with the date of the winning and the depth of the pits (averaged where there are more than one). Using Spearman's rank correlation coefficient, a positive correlation was calculated between the labour ratio and age of winning (rho = + 0.41) and between labour ratio and depth of seam (rho = + 0.55). It seems therefore that by 1844 the new

TABLE 23 : Deployment of colliery labour, 1812, 1828 and 1844

Colliery	Total underground workforce in 1812	Total underground workforce in 1828	Total underground workforce in 1844
Backworth	80 (?)	204	236
Benwell	155	178	136
Cowpen	158	?	240
Coxlodge & Kenton	280	374	231
Collingwood	159	328	
Cramlington		189	524
East Holywell			153
Elswick	83	168	116
Earsdon		272	124
Fawdon	200	202	251
Fenham			121
Gosforth			287
Hartley	158	?	200
Heaton	190	273	305
Holywell		173	110
Killingworth	199	458(+ Burradon)	220
Montague	100		
Monkseaton	80 (?)	116	176
Murton	133		
Percy Main	369	426	256
Plessey	113		
Seaton Burn			258
Seaton Delaval			477
Seghill		211	447
Walbottle	182	209	217
Walker		311	259
Wallsend	298	450	181
Willington	315	405	282
Wideopen		200	296(+ Burradon)
Wylam	126	181	155
Total	3,378	5,328	6,258

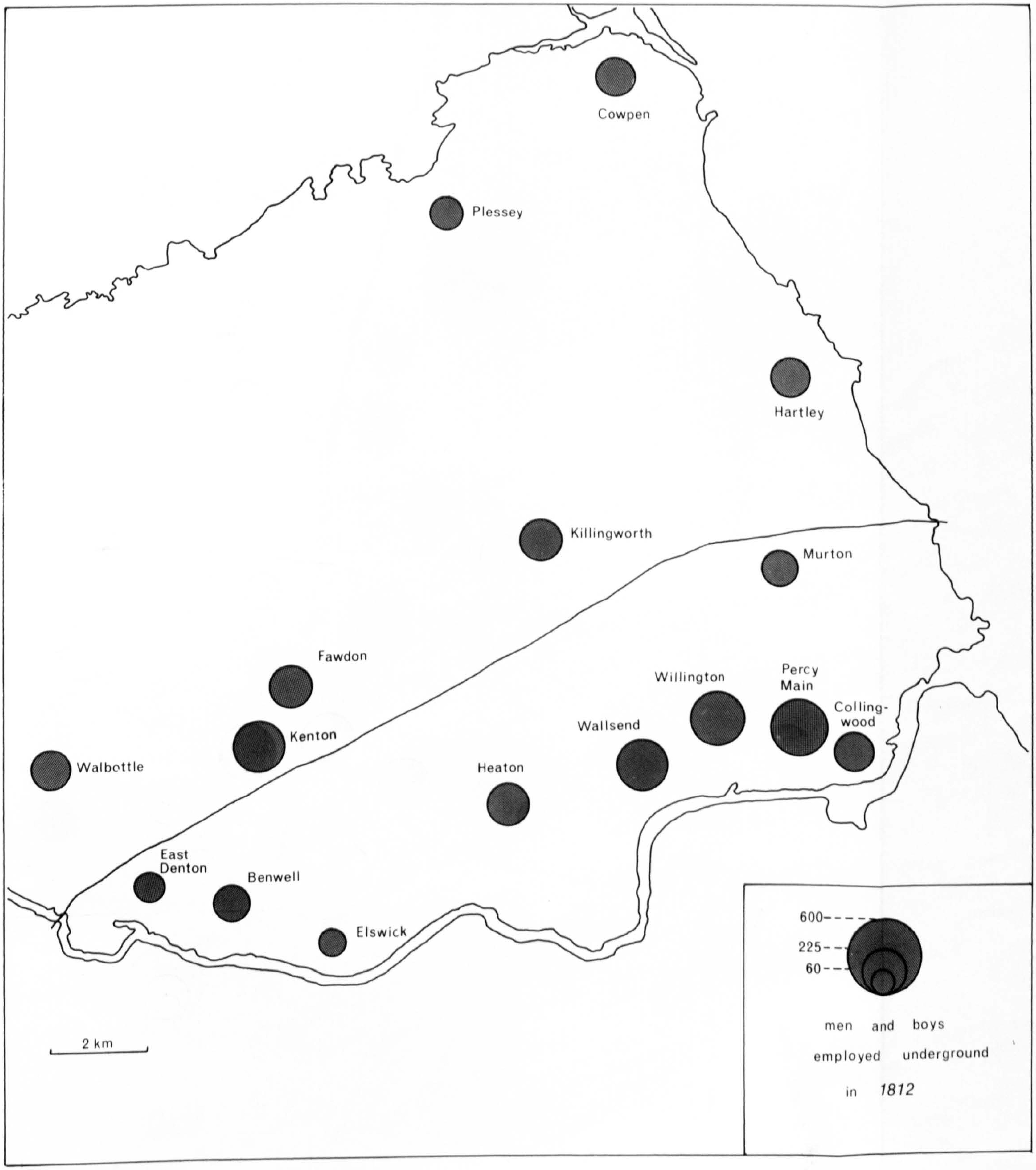

Figure 39 : The deployment of labour in 1812

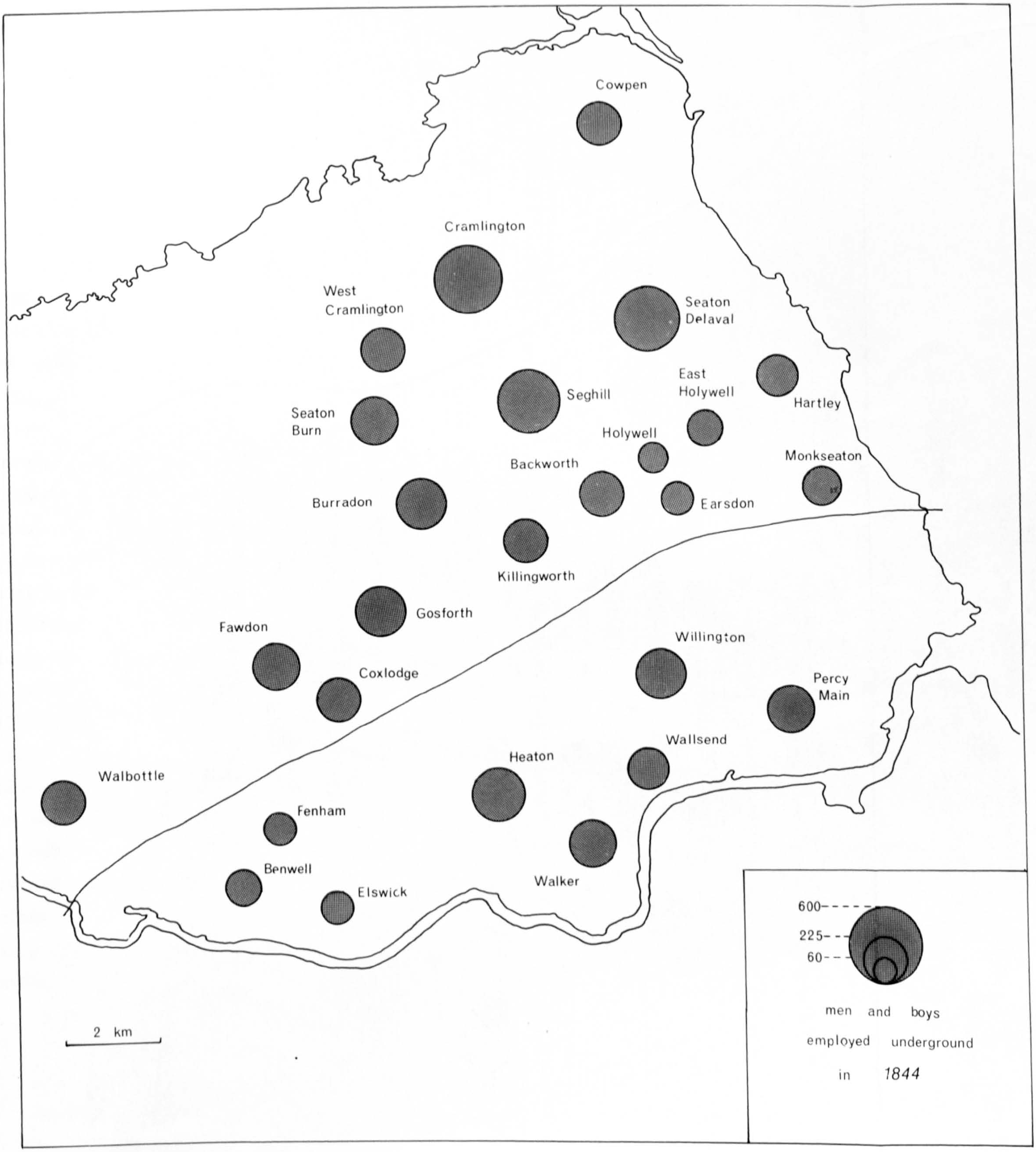

Figure 40 : The deployment of labour in 1844

TABLE 24 : Labour ratio, depth and age of winning in 1844

Colliery	Hewers as % of total underground workforce	Date of winning	Depth (fathoms)
Cowpen	62.5	1800	27
Seaton Burn	58.9	1840	20
West Cramlington	57.4	1840	10
Holywell	57.3	1828	58
East Holywell	56.9	1839	30
Seghill	56.4	1826	25
Seaton Delaval	55.3	1838	42
Monkseaton	53.4	1810	42
Wylam	52.9	1776	39
Hartley	51.0	1830	20
Burradon and Wideopen	49.0	1815	80
Earsdon	48.4	1822	73
Fenham	47.9	1830	30
Killingworth	47.7	1802	105
Cramlington	46.8	1828	21
Walbottle	45.6	1780	82
Backworth	44.5	1818	74
Wallsend	44.2	1778	120
Willington	43.6	1775	95
Heaton	41.3	1790	76
Benwell	40.4	1793	102
Coxlodge	39.8	1808	76
Gosforth	39.0	1825	35
Elswick	38.8	1804	22
Walker	38.6	1818	90
Percy Main	35.1	1799	128
Fawdon	30.3	1810	49

Source: Commission on the state of the population in the mining districts .... Parliamentary Report 1846, vol XXIV, pp 388 - 412.

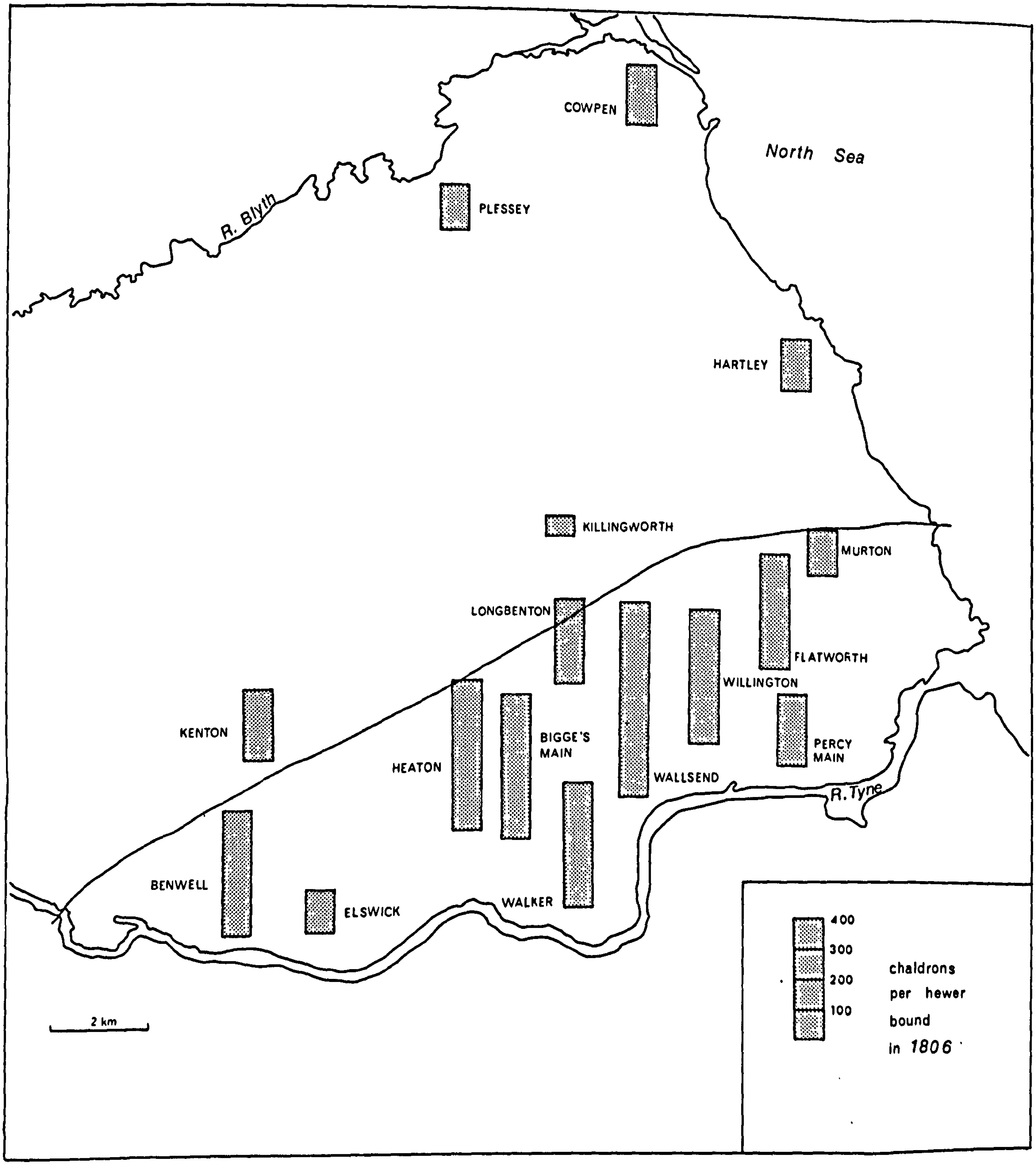

Figure 41 : Labour productivity in 1806

collieries at Seaton Burn, Cramlington, Holywell and Seghill, working shallower coal well to the north of the Ninety Fathom Dyke were more efficient in their use of underground manpower than the older deeper collieries nearer the Tyne. But this would have been counterbalanced, to some extent, by their greater surface haulage costs.

CHAPTER EIGHT

CONCLUSION

This thesis has attempted to illuminate and explain those influences which controlled the spatial development of the coal industry in Northumberland before 1850. The spatial relations of coalmining have been shown to be extremely complex and generalisations about them are therefore hazardous. M.G.A. Wilson's model of pit location in a developing coalfield, which was mentioned in the opening chapter, is nevertheless such a generalisation. But it fails to take into account the following, which have affected the geographical development of coalmining in Northumberland:

1. Variations in the size and spacing of pits due to depth of seam.
2. Variations in the size and spacing of pits due to changing technology.
3. The effects of tectonic disturbance on pit location and patterns of coalmining.
4. The effects of relief (enabling both drainage and coal transportation by gravity) on the locations and nature of mines.
5. The effects of improved winning technology in bringing new areas of coal within the ambit of economical extraction.
6. The effect of the pattern of landownership on the pattern of mining activity.
7. The role of wayleave, affecting the cost of transport (and in the case of negative wayleave even blocking access to the market).
8. The effect of regulation and the limitation of the vend in protecting weaker collieries from competition.

With these omissions in mind it could be argued that Wilson's model has little application in a Northumbrian context.

It would be wrong however to dismiss his hypothesis too readily. All it says is that coalmining will proceed progressively from the shallowest to the deepest coal and from the point nearest to the market to the point furthest away. And at the macro-level this was true in Northumberland, although the movement of mining was convergent due to the synclinal structure of the coalfield. Wilson's basic assumption that "production costs on any coalfield will tend to vary according, inter alia, to depth, distance from the outcrop and seam characteristics, whereas freight charges will, to some extent at least, be affected by the length of on-field haulage" remains sound even when applied to a coalfield as physically and historically complicated as that of Northumberland. But the shortcomings of Wilson's model derive not so much from what it says as from the amount that it leaves unsaid (he did point out many of its shortcomings himself).

Matched against the intricacy of the geographical development of the Northumberland coal industry it indeed appears a pale and hazy portrait. It claims that mining begins near to the outcrops and near to shipping points because haulage and extraction costs are minimised there. In Northumberland the coal near to the surface of manors like Benwell, Elswick and Denton was, it is true, the first to undergo large-scale commercial exploitation. But on Tyneside the outcrops along the western rim of the coalfield were worked much more intensively than those along the eastern rim even though, if anything, the latter were nearer to the market (that is nearer to the coast and to the mouth of the Tyne whence the collier brigs sailed for London). Wilson's model offers no explanation for this. The reason, as has been shown, lies in the close relationship between relief and early coalmining technology. The steep sides of the Tyne Gorge, its tributary valleys and the hilly country around were ideal for 'pit and adit' winnings. On the other hand the disposition of seams within the manors of the flat coastal plain did not favour drainage by gravity to nearly the same extent. Wilson envisages the earliest stage of mining as consisting of tunnel working along the outcrops. Even by 1600, however, this stage was almost over in Northumberland. In the Manor of Benwell in 1631 a group of viewers counted 148 pits and only eleven 'groves' or tunnels.

To say that the spread of mining in Northumberland "followed an orderly pattern consistent with the continuing search for a least-cost location" does not ring true. Undoubtedly shallow mines near to shipping points were cheaper. But the question which Wilson seems to evade, and which is crucial to the interpretation of changing patterns in Northumberland, is whether deep mines near to shipping points were cheaper than shallow mines at a distance from them, or not. Furthermore in Northumberland mining did not begin at the outcrops because it was inexpensive. It began there because the outcrops were the only places where coal was known to exist. Nevertheless it was the outcropping coal nearest to navigable water which was the first to be worked for shipment and there is some evidence subsequently to support a "continuing search for a least-cost location". After all it was part of the role of consultant viewers to predict profit margins prior to the opening of new collieries. Profitability loomed large in choosing between alternative projects, alternative locations. But the range of choices available was usually dictated by technical feasibility. Rarely did the viewers distinguish clearly between technical possibility and profitability although the limits of the former were usually some distance beyond the limits of the latter. Wilson's "periodic substitution of production costs for transport charges and vice versa" seems to correspond to the forces behind the main locational changes in Northumberland, although the mechanism of substitution was geared to technology. In the late seventeenth century the introduction of wooden waggonways activated areas in north-west Durham previously beyond the limits of economic transportation to staith. In the second half of the eighteenth century the more effective use of steam pumping enabled a colonisation of the Wallsend Basin and interrupted the extension of mining in Durham since the 'distant' collieries found it difficult to compete. Then, with the advent of the iron railway and steam traction in the nineteenth century the area to the north of the Ninety Fathom Dyke began to be colonised while the Wallsend Basin waned in importance. At the macro-scale, then, the periodic substitution of winning costs for transport costs was the basis for important locational shifts. But at the local level patterns were so complex and intimately related to tectonics, ownership and human whim that it is much more difficult to apply broad locational principles.

To what extent is it possible to generalise and postdict patterns of coalmining? It has been shown that models like M.G.A. Wilson's are useful as starting points from which to begin detailed investigation, logical assumptions which can be tested against reality. As a basis for the postdiction of precise locations, however, their utility remains in doubt. The chief drawback of Wilson's model - that it fails to account for the way in which changing technology can affect drainage and haulage costs - severely limits the extent of its application in Northumberland, and probably in most older coalfields. Moreover, the adoption and application of new technology was affected by the behavioural eccentricities of human beings, militating further against predictability. It must be concluded that where technological response, geological conditions and patterns of ownership are variable, and where adequate documentation or archaeological exploration allows, postdiction can be no substitute for detailed investigation and reconstruction of patterns of coalmining activity.

APPENDICES

APPENDIX A : Bibliography

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APPENDIX B : A list of the main sources reposited in the strong room of the North of England Institute of Mining and Mechanical Engineers, Neville Hall, Newcastle

WATSON COLLECTION

Shelf 4 (Johnson Collection)

Volume 1:	Leases and agreements, 1717 to 1770
2:	Views and estimates, 1738 to 1786
3:	Views and reports, 1750 to 1755
4:	Papers relating to Willington Colliery, Tynemouth Moor Colliery, East and Little Benton New Winning, Throckley Colliery
5:	Views and reports, 1795 to 1814
6:	Awards and leases relating to Heaton and Spanish Closes, and Little Benton, 1790 to 1800
7:	Leases, Heaton and Benton, 1820 to 1832
8:	Killingworth Colliery, tentale accounts with Matthew Bell, 1801 to 1848
9:	Views and reports, 1827 to 1843
10:	Colliery reports, 1834 to 1851
11:	Sections of strata
12:	Various reports and valuations

Shelf 5

Volume 1:	Deeds
2:	Wills
3 to 7:	Pitmen's bonds
8:	Working memoranda and correspondence of John Watson, 1750 to 1840
9:	John Watson and others, memoranda
10:	Working memoranda of John Watson, relating to the Duke of Portland's estates in Northumberland
11:	John Watson, correspondence
21:	Colliery plans
27:	Colliery sale catalogues

Shelf 6

Volume	1:	Newspaper cuttings and pamphlets regarding coal
	2:	Newspaper cuttings, collieries in north-east England
	4:	Killingworth Colliery minutes, 1836
	6:	Various colliery minutes, 1835 to 1836
	8:	

Shelf 8 (View books)

Volume	2:	Proposal book with extracts of leases for 59 different collieries, including many in Northumberland
	4:	Extracts from the journals of John Watson, 1745 to 1750. References to visits to 32 different collieries.
	5:	View book, 1761 to 1768 (29 views)
	6:	View and boring book, 1701 to 1777 (39 reports)
	7:	Colliery journal and memoranda book, 1740 to 1783
	8:	View book, 1741 to 1808 (over 100 reports)
	9:	View book, 1752 to 1815 (41 reports)
	10:	View book, 1769 to 1779 (over 80 reports)
	11:	View book, 1777 to 1790 (44 reports)
	12:	View book, 1724 to 1784 (44 reports)
	13:	View book, 1734 to 1770 (22 reports)
	17:	Valuation of Backworth Estate, 1816
	19:	Tyne and Blyth vends, 1661 to 1831
	21:	Elswick tentale accounts

Shelf 9 (Watson Bound Papers)

Volume	2:	Backworth and Holywell, 1788 to 1821 Willington and Balkwell, 1794 to 1800
	3:	Benwell, 1814 to 1830
	4:	Bigge's Main, 1792 to 1809
	7:	Brunton, Fawdon and Weetslade, 1767
	10:	Coxlodge and Kenton, 1800 to 1830
	11:	Coxlodge and Kenton, 1811 to 1821
	12:	Coxlodge and Kenton, 1811 to 1818
	13:	Coxlodge and Kenton, 1731 to 1832
	14:	Coxlodge and Kenton, 1811

Volume 18:	Collingwood Main and Chirton, 1785 to 1824
20:	Cowpen, 1791 to 1817
21:	Cowpen, 1818 to 1824
22:	Cowpen, 1825 to 1849
23:	Cowpen, 1850 to 1857
24:	Cowpen, 1858 to 1866
25:	Cowpen, various dates
26:	Cramlington, 1825 to 1838
27:	East Denton and Elswick, 1817 to 1831
28:	East Denton, 1765 to 1818

<u>Shelf 10</u> (Watson Bound Papers)

Volume 30:	Elswick, 1806 to 1830
38:	Gosforth, 1753 to 1836
40:	Hartley, 1805 to 1830
41:	Heaton, 1791 to 1824
42:	Heaton, 1825 to 1836
43:	Heaton, 1738 to 1806
44:	Heaton, 1806 to 1834
49:	Holywell, 1829 to 1832
53:	Jesmond, 1631 to 1829
54:	Killingworth and Longbenton, 1734 to 1813
55:	Killingworth and Longbenton, 1814 to 1820
56:	Killingworth and Longbenton, 1821 to 1832
57:	Killingworth and Burradon, 1749 to 1837

<u>Shelf 12</u> (Watson Bound Papers)

Volume 62:	Byker, Heaton and Lawson Main, various dates
69:	Murton, Kenton and Hartley, 1806 to 1815
70:	Murton, 1798 to 1814
72, 73 & 74:	Newcastle Corporation wayleave rents, 1794 to 1832
86:	Ouseburn and Redbarns, 1806
88:	Dinnington, Prestwick and Mason, 1753 to 1863

<u>Shelf 13</u> (Watson Bound Papers)

Volume 90:	Redbarns and Ouseburn, 1786 to 1820
91:	Regulation of coal trade vends, 1839 to 1858
95:	Seghill, 1808 to 1831

Volume 98 & 99:	Tynemouth Moor division, 1788
103:	Walker, 1782 to 1817
104:	Walker, 1818 to 1832
105:	Wallsend and Percy Main, 1805 to 1834
110 & 111:	Willington, 1773 to 1832
112:	Willington, 1805 to 1808
113:	Wylam and Heddon, 1792 to 1829

Shelf 11 (Miscellaneous colliery papers and books)

Volume 1:	Engineering drawings, coal haulage and pumping
6:	Engineering drawings, St Anthony's and East Benton
7:	Proposals, 1798 to 1792
8:	Report book, 1775 to 1785
9:	Report book, 1791 to 1794
10:	Report book, 1784 to 1790
12:	Lease extracts and agreements, 1765 to 1795
13:	Report book, 1791
18:	Memoranda of history of the coal trade, written c. 1821

Shelf 16 (Brown's books)

Volume 1:	Letter book, 1749 to 1756
2:	Letter book, 1765
3:	Part of William and Richard Brown

Shelf 17 (Easton's books)

Volume 1:	View book, 1802 to 1825
3:	Typed copy of a 'Journal of the Coal Trade' by Matthias Dunn, 1812

Shelf 18

Grand Allies Partnership Minute Book, 1727
Richard Peck's View Book, 1710 to 1735

Shelf 37 (Watson Collection Lease Books)

Volume 1:	Backworth and Holywell, 1817 to 1819
2:	Bigge's Main Byker and Wallsend, 1785
4:	Chirton, 1806
5:	Cowpen, 1824

Volume 8:	Heaton, 1791
11:	Miscellaneous colliery papers, 1786 to 1835

WATSON COLLECTION BOUND PLANS

Shelf 19	Earsdon Parish, 33 plans
Shelf 20	Cramlington, Dinnington and Stannington Parishes, 17 plans; Longbenton Parish, 25 plans
Shelf 21	Tynemouth Parish, 34 plans
Shelf 22	Wallsend Parish, 30 plans
Shelf 23	Newburn and Heddon Parish, 20 plans
Shelf 24	Northumberland: General plans, 40 plans
Shelf 25	Northumberland: General plans, 33 plans
Shelf 26	Gosforth and Fawdon Parishes, 31 plans
Shelf 27	All Saints, Newcastle Parish, 30 plans
Shelf 28	St John's, Newcastle Parish, 28 plans

THE BELL COLLECTION

Shelves 14 & 15	This comprises 22 volumes of bound miscellaneous papers entitled 'History of Coal and Mining'. It mainly consists of newspaper cuttings, articles from journals, pamphlets, advertisements, etc., dealing with the period 1750 to 1850.

THE T.E. FORSTER COLLECTION

Shelf 49

Volume 4:	The Barnes View Book (over 100 reports)
5:	Peck's View Book, 1710 to 1757
7:	View book (30 reports)
8:	View book, 1805 to 1840 (50 reports)
9:	View book, 1809 to 1823 (23 reports)
13:	Matthias Dunn's view book (32 reports)
14:	Matthias Dunn's view book, 1811 to 1826
15:	Matthias Dunn's view book, 1832 to 1836
16:	Matthias Dunn's view book, 1813 to 1830
17:	Thomas Forster's view book, 1830 to 1832

THE BUDDLE COLLECTION

See 'The papers of John Buddle, colliery viewer, in the Mining Institute, Newcastle on Tyne; an annotated list and assessment of their value to the economic historian', by F.S. Hewitt, MA., thesis. A copy is kept in the strong room.

This comprises a large collection of view books representing the life work of John Buddle, junior, perhaps the most important of the nineteenth century viewers. It contains a large amount of useful information relating to the coal trade in general but the most important sources for Northumberland have been:

Volume 6:	Views of Fawdon (1812), Walbottle (1813), Cowpen (1813), Callerton (1794), Cowpen (1817)
14:	Fawdon and Brunton (1799), Cowpen (1803) Heaton (1802)
15:	Killingworth, Elswick, Heaton (1806)
17:	Wallsend

VARIOUS

Shelf 36 (Unthank Papers)

A variety of plans and drawings, 1757 to 1772

Shelf 38 (Miscellaneous plans and colliery data)

Volume 1:	Wylam, Callerton, Tynemouth and Killingworth
6:	Heaton Leases

Shelves 39 to 43 — Rolled geological plans

Shelf 45 (Buddle-Atkinson Papers)

Volumes 1 to 7: Buddle papers relating to various collieries

APPENDIX C : A report by William Brown on the state and potential of Kenton Colliery in 1776

This colliery has been won and wrought many years ago before the memory of any man now living, various seams of coal found in it the uppermost of which is called the Stone Coal, is about 34 inches thick, is much wrought and lies from 3 or 4 fathoms to about 40 fathoms deep. The next seam of coal is about 4½ feet thick, is called the Main Coal and very extensive workings have been made in it. These workings are on the NW side of a very great dyke. There has been some workings on the S side of the said dyke near the SE corner of what is called East Kenton, but the works there have been of little consequence ... there has been likewise some workings on the south side of the said dyke in the SW parts of West Kenton adjoining Benwell estate and in a seam called the Benwell Main Coal and indeed that part of Benwell was won by a communication thro the above-named dyke running thro Kenton and the water drawn at Slatyford on the north side of the dyke was so thrown into Benwell waste, which took off about 30 fathoms of the lift, but if the level had been drove truly thro Benwell it would have laid the Main Coal pits at Slatyford dry without drawing water at all. There is a quantity of the said Benwell coal yet to work on the S side of the said dyke a seam of coal one yard thick called the Denton Low Main Coal ... neither the last mentioned nor the Beaumont Seam has ever been sunk to or wrought in any part of Kenton estate.

There is also yet to work in Kenton (on the N side of the Dyke) a very large tract of main coal partly on the SE., S., E., and NE of East Kenton and a great part of that coal may be laid dry by a level to be drove up truly from the River Tyne, nor do I think Kenton Colliery of much value unless such a level be drove for all the old levels are now ruined and stopp'd up and the quantity of water now bred in and now standing in old workings and that falls in from hundreds of falls to the surface of the earth which goes into the wastes of that colliery in wet and rainy seasons is so great that I am not able to say that fire engines would draw it.

There is a seam of coal called Newbiggin Stone Coal that lies under the Kenton Main Coal and some workings have been made near the Quarry in her adjoining Newbiggin Boundary, I have seen and been in this seam of coal many years ago and to the best of my memory she is about 3 ft thick and is undoubtedly unwrought in most parts of Kenton on the N side of the great dyke.

Explanation of plan:

a,a,a. Old water-level pits in Benwell

b,b,b. Old water-level pits in West Kenton S of the Dyke

C. The place where the Main Coal was won and the water delivered into Tyne Level at Slatyford.

d,d,d,d,d,d,d,d. Old water-level pits in West Kenton and the Main Coal is all wrought to the west and NW of that line and the Stone Coal is wrought likewise to the south of that line.

e,e,e,e,e,e. Water-level pits in East Kenton and the Main Coal is wrought to the west and SW of that line.

F. A place where the main coal was won last and the water was drawn at that place.

f,f,f,f. Old water-level pits by virtue of the last winning and the coal is wrought to the west and SW of that line.

About 500 acres in West Kenton is wrought in the Main Coal and about 60 in East Kenton is also wrought in that seam and there appears yet to work in the Main Coal on the north side of the dyke in the two Kentons about 460 acres ...

Quantity of coal yet to work in East and West Kenton allowing to be lost in pillars:

460	acres	Main Coal north of dyke	4' 6"	47,000	tons
250	"	Stone Coal	2' 10"	16,000	"
240	"	Benwell Main south of dyke	4' 0"	21,000	"
270	"	Beaumont Seam "	3' 6"	20,000	"
270	"	Denton Low Main "	3' 0"	18,000	"
				122,000	

Source: Newcastle Central Library, Colliery MSS, vol E, p 47.

APPENDIX D : An estimate by John Watson of the cost of winning Gosforth Colliery in 1816

Estimate of the expence (sic) of sinking a pit on the south or upper side of the Great Downcast Dyke, and driving a stone drift from the same for the purpose of winning the High Main Coal Seam under Gosforth Estate, belonging to Charles J. Brandling Esq., which lies on the north side of the said dyke where it is calculated the coal will be at a depth of 128 fathoms from the surface.

Main engine, 100 H.P., erected in a stone house, including 13 fathoms of 10 inch pumps, two 14 feet boilers wood, iron, brass, lead, copper, and all other materials to complete the same	£5,500 - 0 - 0
Sinking the pit, 12½ feet diameter, including sinkers wages (25 sinkers 22s. per week - Candles £1-10-0.) say 128 fathoms at £16 per fath.	£2,048 - 0 - 0
Timbering	£432 -10 - 0
Cleading, where stone is bad but not so bad as to require backing deals including nails and jointing, suppose 60 fathoms at £9-10-0.	£570 - 0 - 0
128 fathoms of double brattice with memel timber for buntons at £6-6-0.	£806 - 0 - 0
Stock of sinking and drifting gear	£191 - 0 - 0
Corves	£95 - 0 - 0
Sinking gin, including rollies and pulling frames	£55 - 0 - 0
1 pair of ropes for ditto, 133 faths.	£33 - 0 - 0

1 winding engine, 32 h.p., capable of raising 50 20-peck corves in 12 hrs. with boiler & pair of 6 in. ropes	£1,695 - 0 - 0
Driving 120 yards of stone drift from the bottom of the shaft 'till it cuts the coal on the north side of the dyke, including the banksman and machine men's wages at £4-10-0 per yard.	£540 - 0 - 0
Timber, necessary to support the drift previous to its being arched	£14 - 0 - 0
Arching and walling stone drift (7ft.6ins. high) with a 10 in. wall on each side and also a wall in the middle 15 ins. thick, including bricks, lime and labourage 120 yards at £3-6-0.	£396 - 0 - 0
Metal rolley way along stone drift including sleepers, nails at 7-3d per yard.	£43 -10 - 0
8 draught, gin and crab horses at £30 each	£240 - 0 - 0
Keeping horses 2½ years at £41 p.a. (78 weeks sinking, 39 weeks drifting - 117 weeks or 2½ years.)	£738 - 0 - 0
Heap stead and 2 screens	£267 - 0 - 0
Heap and sinking lamps, scraps and shovels	£25 - 0 - 0

140 workmen's houses at £60	£8,400 - 0 - 0
Smith's shop	£55 - 0 - 0
Joiner's shop	£50 - 0 - 0
Office	£80 - 0 - 0
Storehouse	£50 - 0 - 0
Sinkers' Lodge	£8 - 0 - 0
Saw Pit	£36 - 0 - 0
Stables	£630 - 0 - 0
Furnace underground	£70 - 0 - 0

Furnace boiler plate	£15 - 0 - 0
Air tube at bank	£75 - 0 - 0
Corving house	£55 - 0 - 0
	(£9,524 - 0 - 0
Waggon Way. 280 yards of main way to junction with Coxlodge Way, including sleepers, nails and labourage at 14s.	£196 - 0 - 0
Cartage of all materials exclusive of keeping horses (Labour wages 16s. 117 weeks)	£187 - 0 - 0
Sundry labouring attending winning	£380 - 0 - 0
Staithman and Off Putter's houses and office	£250 - 0 - 0
Binding Coal workmen, lads and waggonmen (First year)	£374 - 0 - 0
Two letting-down engines for underground including ropes. Also 2 cranes	£40 - 0 - 0
Leather, flannel, sacks, tin lamps, trapping for cart, waggon & gin horses	£180 - 0 - 0
Two coop and two long carts	£64 - 0 - 0
Coals for machines and workmen (30 workmen per week) during the winning	£737 - 0 - 0
Surgery	£30 - 0 - 0
Damaged ground	£81 - 0 - 0
Shovells, spades & hacks for labourers	£12 - 0 - 0
Trams, shovells and barros for staith	£6 - 0 - 0
280 yards of by way at 14s. per yard	£196 - 0 - 0
100 yards of way in branches at 14s. per yard	£70 - 0 - 0

Checks, check plates, switches and bolts at branch ends near the staith	£7 - 0 - 0
900 yards of penning at 15-10d (50 bricks per yard 1-6d, paving 4d)	£82 -10 - 0
Making a battery to form a junction with Kenton and Coxlodge Way	£100 - 0 - 0
Waggonway to lead from the Kenton Way to where it is supposed the staith will be erected including the bye-way and branches on the staith with nails, sleepers, laying and c. 1600 yards at 14s.	£1,120 - 0 - 0
Erecting a staith capable of holding 3,000 chaldrons of coals	£3,000 - 0 - 0
72 chaldron waggons at £24	£1,278 - 0 - 0
2 ballast waggons at £14	£28 - 0 - 0
36 waggon horses at £35	£1,260 - 0 - 0
Agency office, expences and stationery during the winning (Wages. Viewer £200p.a. Clerk £100 p.a. Storekeeper £75)	£978 - 0 - 0
Rollies, corves, trams, tramplates, and other underground materials necessary for commencing coal work	£360 - 0 - 0
Rolly horses for underground, 8 at £20	£160 - 0 - 0
Trapping for ditto	£9 -12 - 0
Props	£30 - 0 - 0
Timber for colliery purposes	£150 - 0 - 0
Candles (excl. those used in sinking), tallow, grease for sundry purposes during the winning	£190 - 0 - 0

Wages to sinkers for lost time	£110 - 0 - 0
Turnpike gates, postage of letters and water carriage of materials	£45 - 0 - 0
Sundry allowances given to workmen during winning	£52 -10 - 0
Sundries omitted which come under no particular heading	£608 -11 - 0
Lessees and taxes	£75 - 0 - 0
Total	£36,211 -12 - 0

The foregoing estimate is founded upon the assumption that the whole of the materials for winning the colliery are new, and that no aid or facility is had from either of the collieries belonging to Mr Brandling at Felling and South Gosforth, consequently any assistance had therefrom or any materials which can be furnished from either of these concerns, in aid of the winning, will of course be a diminution of the above sum according to its (sic) respective worth.

APPENDIX E : Coal measure in 1828

according to Buddle

Cubic inches (solid)	Cubic feet	Gallons	Pecks	C.W.T.	Bolls	Fothers	Waggons	Chaldrons	Keels
268.8	016.6	1							
1209.6	0.7	4.5	1						
9676.8	5.6	36	8	2.208	1				
77414.4	44.8	288	64	17.666	8	1			
183859.2	106.4	684	152	41.958	19	2.75	1		
232243.2	134.4	864	192	53	24	3	1.26	1	
1857945.6	1075.2	6912	1536	424	192	24	10.1	8	1

Conditional tens:

20 waggons c. 22 bolls = 440 bolls = 1 ten
24 waggons c. 24 bolls = 576 bolls = 1 ten

Source: NEIMME, Buddle Coll., vol 25, p 17

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S. J. TELFORD

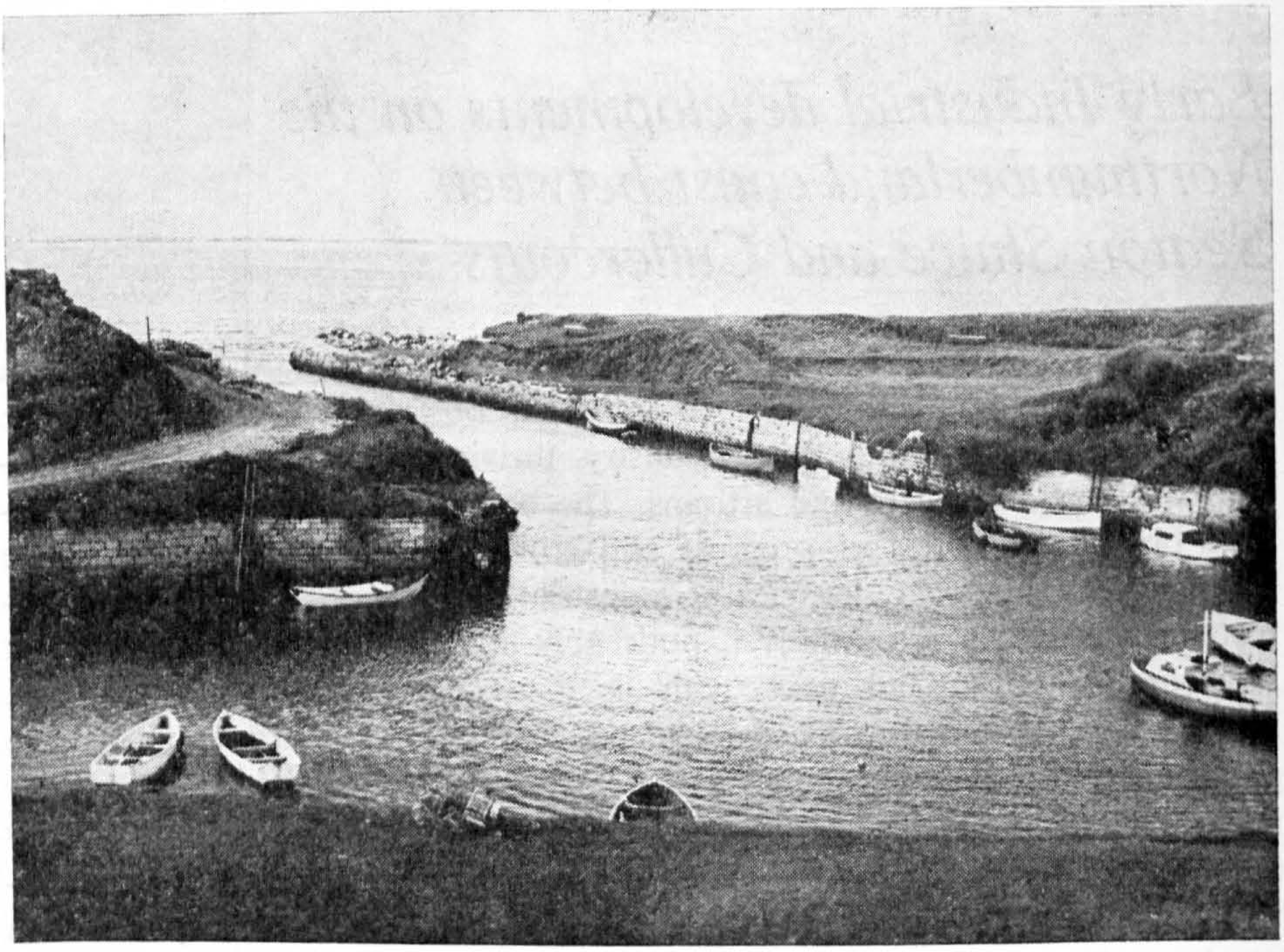
Early Industrial developments on the Northumberland coast between Seaton Sluice and Cullercoats

There is little today in the character of the Northumberland coast between Blyth and Tynemouth to suggest to the casual observer the former existence of extractive and manufacturing industry, thriving commerce and communities of miners, mariners and artisans. The coal trade and its related industries brought centuries of progress and growth to the nearby River Tyne but also, in their wake, legacies of industrial blight and inertia. Such manifestations of decay are, however, noticeably absent from the low south-east Northumberland coastal tract, with its medley of dormitory settlements, holiday beaches and threatened farmland. Nevertheless, this area must have presented a profoundly different aspect to the eighteenth-century eye for, by then, it had become the theatre of extensive coal-mining and shipping with associated salt, glass and copperas production. Industrial activity was relatively short-lived, however, and the veneer of the twentieth century has done much to disguise the visual remains of the area's former industries, but a few interesting indications of their past presence can still be seen. The aim of this paper is to describe the development of the former industrial landscape from literary and documentary sources and the imprint on the ground.

The development of shipping facilities

Seams of coal representing the eastern lip of the Wallsend Coal Basin exist at shallow depth adjacent to the coast, and outcrops of the Yard, Bensham and Low Main seams encouraged the working of coal here from the thirteenth century for local domestic use and for heating large pans to evaporate brine into salt.[1] Distance from the Tyne and the consequent cost of overland carriage of coal precluded large-scale expansion, however, until the second half of the seventeenth century when local landowners developed shipping facilities at Hartley Pans and Cullercoats with an eye to the growing London and east coast markets for coal and salt. Prior to this it was necessary to carry salt made at Hartley Pans to Blyth in wains, making the saltworks there less economical, while coal, which was less valuable than salt per unit weight, could not be marketed profitably at all.

In response to the need for shipping facilities and to the growing potentialities of the coal trade, Sir Ralph Delaval in 1670 expended some £7,000 in constructing a harbour at the mouth of the Seaton Burn large enough to berth fourteen vessels.[2] The scheme involved the building both of a pier



The entrance to the Old Harbour at Seaton Sluice, now a haven for pleasure craft

and of sluice gates at the head of the harbour which would dam back the water of the burn at high tide and release it at low tide, the deluge removing sand and silt from the harbour entrance. It was, in fact, a cheap and effective substitute for dredging. The harbour was in an exposed position, however, and the navigation of the entrance, involving an oblique approach, remained a hazardous undertaking in bad weather. Moreover, the pier sustained frequent storm damage and, in 1676, had to be strengthened 'at an immense cost . . . with dovetails of heart-of-oak let into the stone'.[3] The settlement which developed around the harbour became known as Seaton Sluice instead of by the older name, Hartley Pans.

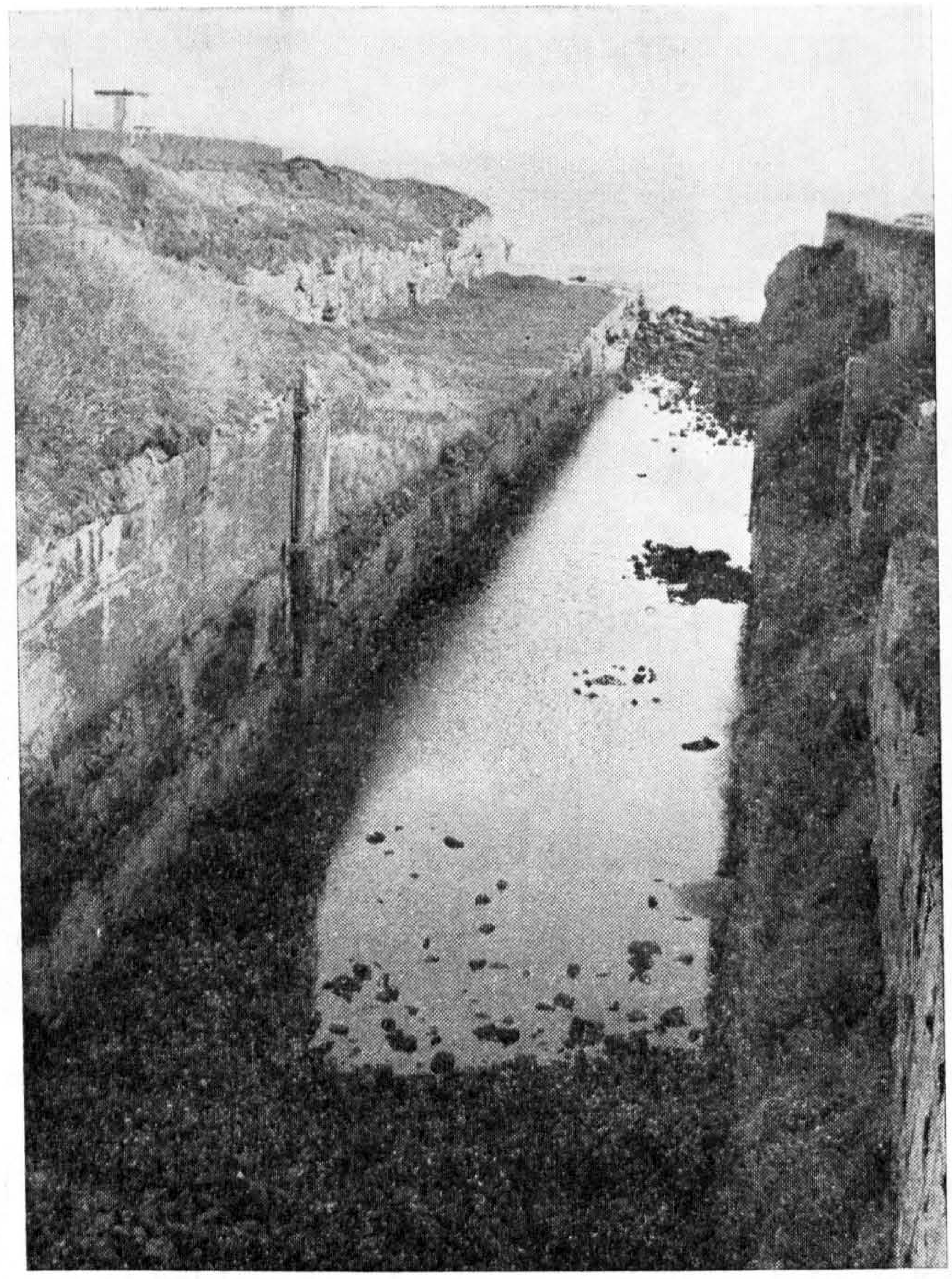
Two miles south of Seaton Sluice a similar development was taking place on the Whitley estate of the Percy family, where in 1677 a pier was erected in the sandy haven of Cullercoats at a cost of over £3,000 for the embarkation of coal from Whitley Colliery. Again, however, the pier proved vulnerable to the destruction of the sea and, on 10 October 1710 'the outworks of the pier or harbour were in one tide's time demolished and razed to the ground'. The cost of repair was computed at between £1,000 and £1,200.[4] Changes in shipping technology paved the way for larger vessels, the use of which exposed the limitations of the harbour still further. The average size of the 224 cargoes cleared from Cullercoats in 1679 was only 64 tons, while

The Old Harbour looking towards the site of the former sluicegates

the corresponding figure for the 138 cargoes despatched in 1714 was 135 tons.[5] The decline of Whitley and Monkseaton Collieries and of the salt pans which depended on their poorer grades of coal led to the cessation of commercial activity at Cullercoats by 1726.

The same fate might well have befallen neighbouring Seaton Sluice but for the potential of its coal-bearing hinterland and the entrepreneurship of the Delaval family. The harbour was becoming increasingly inadequate by the middle of the eighteenth century, and shipowners began to threaten to boycott the port unless the harbour was 'made safe and commodious'.[6] In consequence, John Hussey Delaval and his younger brother, Thomas, resolved to construct a new deep-water dock incorporating an additional entrance to the harbour, where vessels could be loaded by spouts and cranes at all states of the tide. The result was the 'New Cut', as it was called, 30ft wide, 52ft deep, and carried through 900ft of solid rock at a cost of £10,000. It was begun in 1761, opened on 20 March 1764 and hailed as one of the great engineering feats of the day.[7]

The construction of the New Cut offset the navigational difficulties of the small and confined harbour at Seaton Sluice for almost a century but only served to postpone its decline in the face of new shipping technology and,



The New Harbour or 'Cut' at Seaton Sluice looking towards its seaward entrance

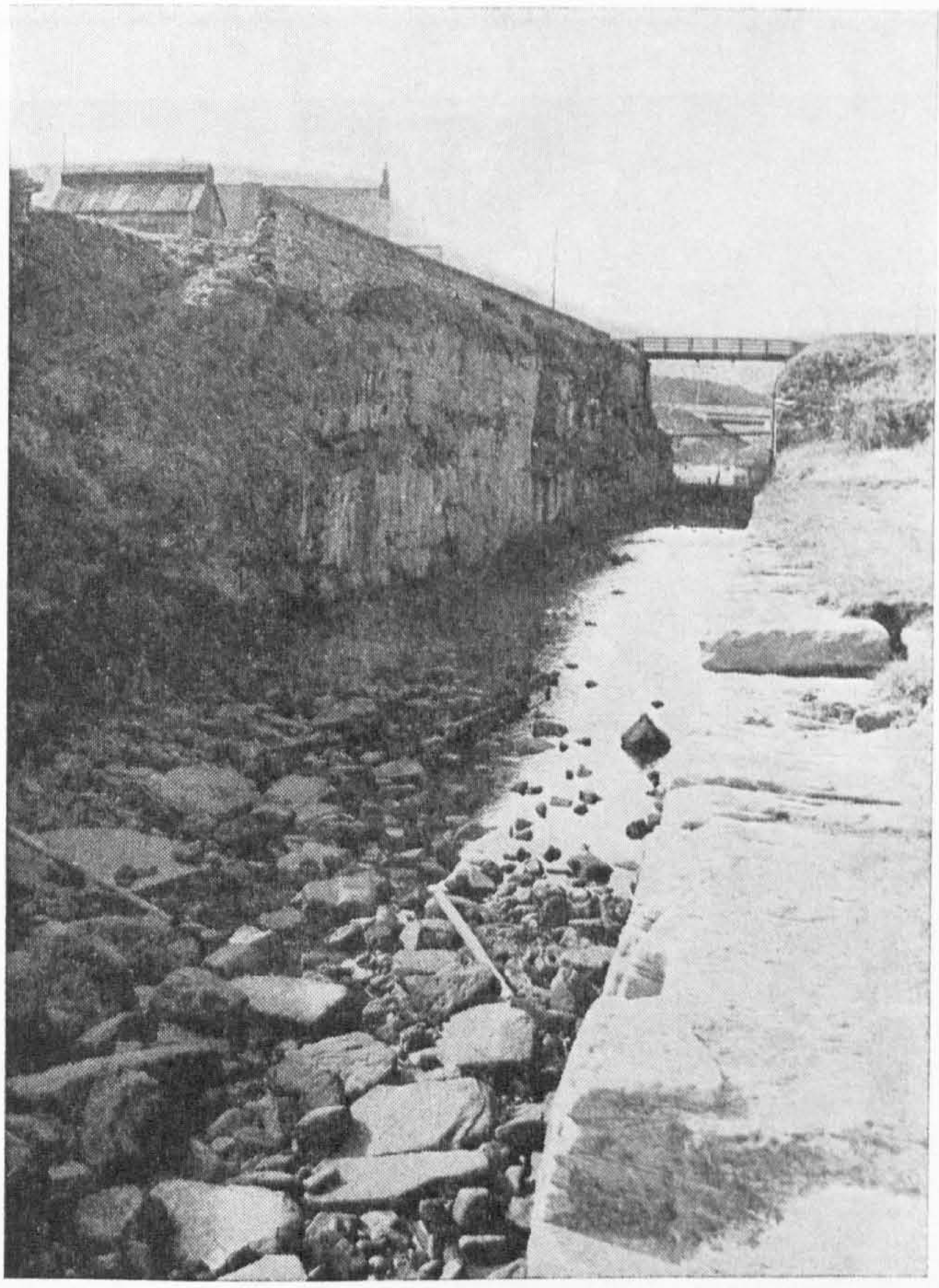
especially, the advent of the screw-driven iron collier. In 1848 one of the lessees of Hartley & Cowpen Collieries declared [8]:

> we ship our Hartley coals at Seaton Sluice. Sometimes for ten weeks together a ship cannot get to sea from that port and it is of the utmost importance to the well-being of the colliery that we should get a better place of shipment.

The outcome was a railway link with the Tyne and the gradual decline of commerce at Seaton Sluice to a negligible level by the 1860s. The Hartley Colliery disaster of 1862 and the subsequent closure of the Hester Pit provided the final fatal blow.

The growth of coal-mining

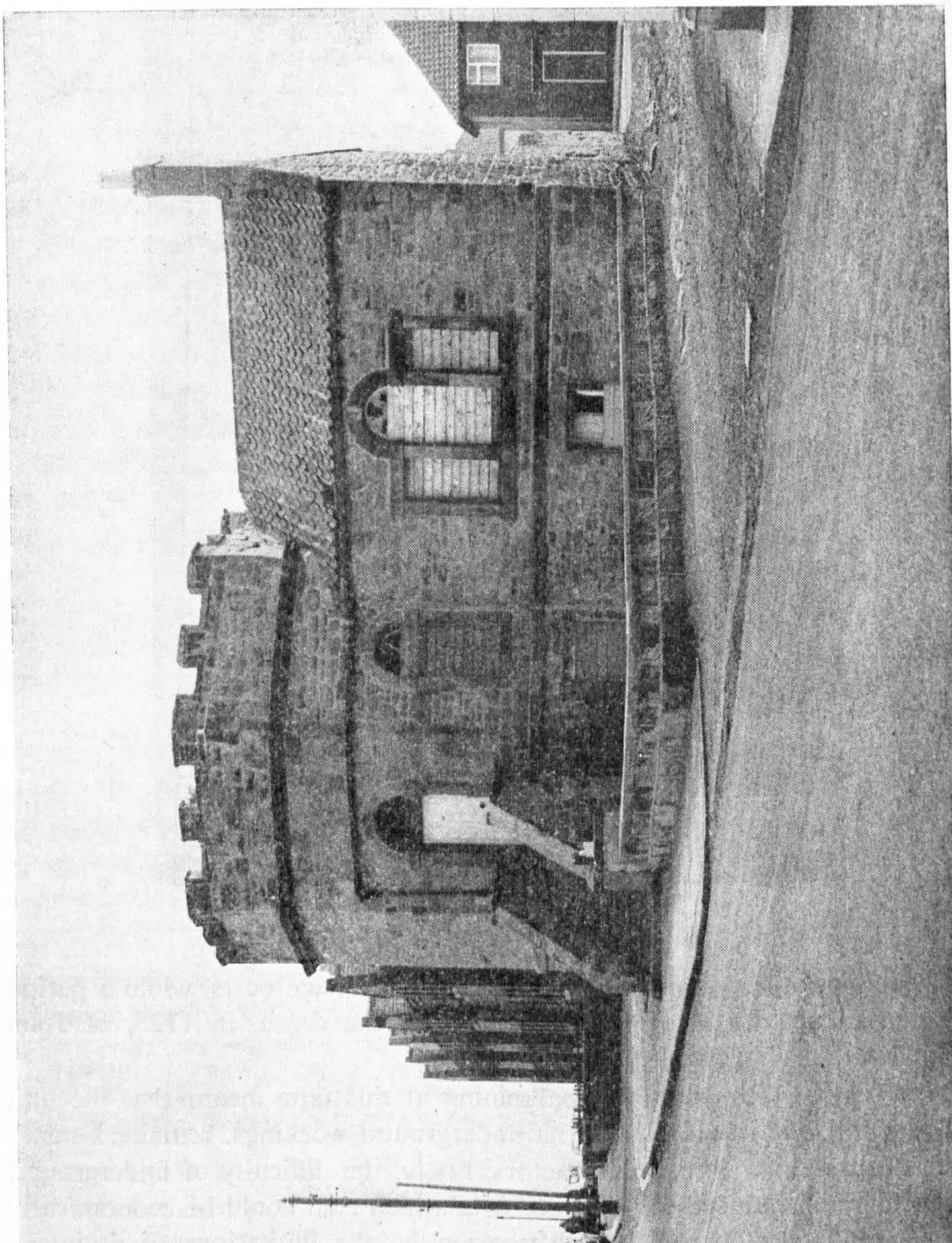
Intense industrial activity following the initial development of the two ports mainly took the form of coal-mining and salt-making. The upper seams of coal beneath the estates of Hartley, Whitley and Monkseaton were extensively worked until 1725. By that time the pits in Whitley and Monkseaton



The New Harbour

were becoming uneconomical owing to higher drainage costs, while a period of decreased activity at Hartley ensued after the death, in 1725, of John Rogers, lessee of that royalty.

The primitive technology of coal-mining at this time meant that the unit of production, the single pit and its underground workings, remained small. This was a result of three main factors; firstly, the difficulty of underground transport, which reduced the distance over which coal could be economically brought to the bottom of the shaft; secondly, the limitations of drainage, which meant that if workings became too extensive the reception of water from underground 'feeders' exceeded the capacity of early pumping apparatus; and thirdly, primitive ventilation which could not overcome the dangers of asphyxiation and explosion at greater distance from the surface. Owing to the considerable number of shafts required to work a given tract of coal the landscape impact of mining at this time was relatively great and its expansion could entail much despoilation of agricultural land (see Fig 1).



The Octagon, former port office and customs house at Seaton Sluice and the only remaining eighteenth-century building

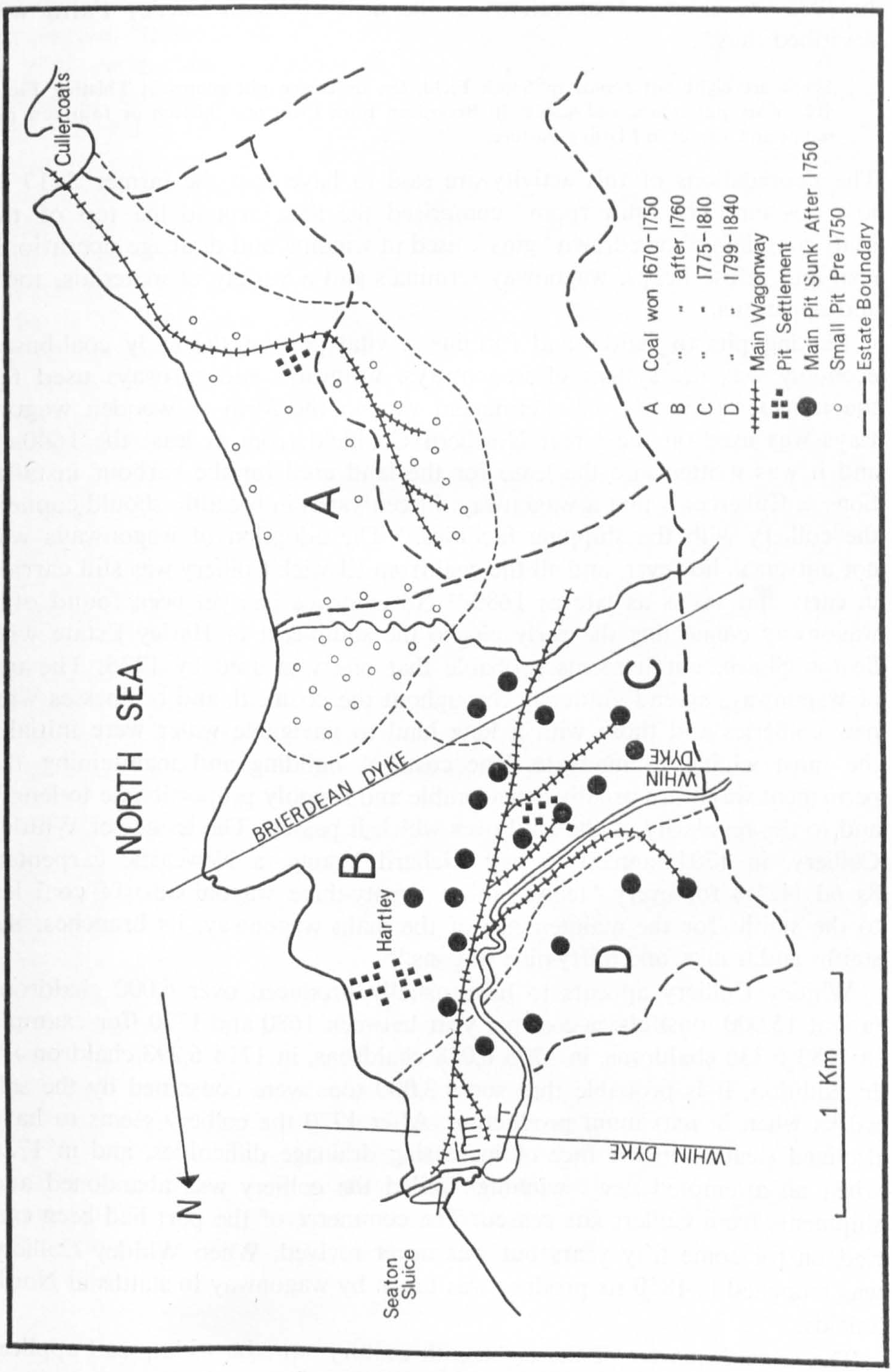


Fig. 1 The Coal-mining Landscape 1670–1840
(From maps and plans in the Bell Collection, Northumberland County Record Office)

In 1732 the extent of operations in the field of South Hartley Farm was described thus [9]:

> There are eight pitt rooms in South Field, ten or eleven pitt rooms in Thistley Field, five or six pitt rooms and staples in Breardean Burn Field and thirteen or fourteen pitt rooms and staples in Flatting Pasture.

The depredations of this activity are said to have cost the farmer £417 in lost revenue. The 'pitt room' comprised the area around the top of the shaft containing horsedrawn 'gins', used in winding and drainage operations, coal and refuse heaps, wagonway terminals and a variety of materials, tools and apparatus.

Linking pits to staiths and forming a vital part of the early coal-based economy was the system of wagonways, wainways and cartways used for the transportation of coal. Permanent way in the form of wooden wagonways was used on the Great Northern Coalfield from at least the 1640s [10] and it was written into the lease for the land used for the harbour installations at Cullercoats that a wagonway, fifteen yards in breadth, should connect the colliery with the shipping facilities.[11] The adoption of wagonways was not universal, however, and all the coal from Elswick Colliery was still carried in carts and wains as late as 1680.[12] No evidence has yet been found of a wagonway connecting the early pits to the south-east of Harley Estate with Seaton Sluice, but it seems probable that one was used by 1725. The use of wagonways spread gradually throughout the coalfield, and businesses with new collieries and those with a long haul to navigable water were initially the most willing to innovate. The costs of building and maintaining the permanent way were usually considerable and roughly proportionate to length and to the regularity of the land over which it passed. The lessees of Whitley Colliery, in 1704, agreed to pay Richard Young, a Newcastle carpenter, 8s 6d (42½p) for every 'tenn' (about twenty-three wagonloads) of coal led to the staiths for the maintenance of the main wagonway, its branches, the staiths and trunks, and thirty-nine wagons.[13]

Whitley Colliery appears to have usually produced over 6,000 chaldrons (about 15,000 tons) of sea-coal per year between 1680 and 1720 (for example in 1683 6,336 chaldrons, in 1705 6,018 chaldrons, in 1714 6,293 chaldrons).[14] In addition, it is probable that some 3,000 tons were consumed by the salt works when in maximum production. After 1720 the colliery seems to have declined steadily in the face of increasing drainage difficulties, and in 1726 when an attempted new 'winning' failed the colliery was abandoned and shipments from Cullercoats ceased. The commerce of the port had been carried on for some fifty years but was never revived. When Whitley Colliery was reopened in 1810 its produce was taken by wagonway to staiths at North Shields.

The second quarter of the eighteenth century saw the widespread application to coal-mining of large-scale, comprehensive, underground drainage schemes made possible for the first time by the use of the Newcomen pumping engine. Although the atmospheric engine was introduced to the coalfield in 1713 its use was at first limited by the initial cost of about £1,200 for a 'cylinder' and its transportation from Coalbrookdale in Shropshire.[15] Until the cost-benefit utility of the engine was proven beyond doubt, and until methods had been devised for its application to the drainage of coal seams, its adoption was gradual, but by 1730 it was beginning to cause considerable changes in the mining landscape enabling larger tracts of coal to be worked from fewer pits and bringing a new landscape feature, the engine house, to the surface of the coalfield.

By 1727 the running of Hartley Colliery had devolved upon Sir John Delaval and a long and formative period of direct involvement of the Delavals in industrial enterprise began. Although some new pits were opened north of the Brierdean Burn before 1750, the main phase of mining expansion at Hartley took place after that date. The making of a new 'winning' between 1758 and 1763 marked a turning point in the development of the colliery.[16] It enabled the exploitation for the first time of the deeper coal north of the Brierdean Dyke and involved the use of three atmospheric engines including one 'great cylinder'.[17] The deeply-incised Seaton Burn could be used for outlets from drainage 'drifts' driven from engine-pit shafts. These facilitated drainage by reducing the height to which it was necessary to raise water. William Brown, one of the most eminent colliery engineers of the day, was employed in the erection of the engines,[18] while Joseph Oxley succeeded in harnessing a Newcomen engine to the drawing of coal, an innovation which excited the attention of James Watt who visited Hartley to inspect the engine in 1768.[19]

The new 'winning' of 1758–63 initiated a movement of mining operations north-westwards from the vicinity of the Yard and Bensham seam outcrops in the south-eastern part of the Hartley Estate. By 1770 the colliery employed 300 workers and its productive capacity was boosted to over 20,000 chaldrons per year.[20] In 1775 another 'winning' was completed in the south-west of the estate with a long wagonway connection to the harbour[21] and in 1777 the colliery produced a record 30,680 chaldrons of sea-coal. By the end of the eighteenth century the most accessible seams to the south of the Seaton Burn were becoming exhausted and the opening of the Nightingale Pit in 1799 represented the beginning of the last phase in the development of the colliery. Between 1799 and 1845 a number of pits worked that part of the royalty north of the Seaton Burn, but by this time Hartley had been overshadowed by the ascendancy of deep mining at collieries further inland and nearer the centre of the Wallsend Basin.

Salt, glass and copperas production

The manufacture of salt by the evaporation of sea water was carried on at Hartley from medieval times and the need for fuel to heat pans was a factor in the early growth of coal-mining.[22] The moderate quality of Hartley coal meant that there was always an abundance of cheap 'pan coal' for use in the salt works, but suitable sites where brine could be pumped from sea-level sumps to the pans were restricted to the low cliffs at the mouth of the Seaton Burn. Nevertheless, a small community of salters had developed at Hartley Pans by the seventeenth century. The potential for salt production at Hartley was always limited, however, and it was the excess of refuse (ie small or dust) coal over that consumed by the salt pans which encouraged the growth of copperas and glass manufacture there in the second half of the eighteenth century.

Whether the development of salt manufacture was visualised when the Cullercoats project was undertaken in 1676 is difficult to establish, but in the following year a South Shields salt merchant named Thomas Fearnon was leased a parcel of ground for the erection of two salt pans and given liberty to ship his produce from Cullercoats.[23] Two years later the shipment of salt was 118 tons.[24] In 1683 it had increased to 179 tons [25] and by 1705 prodigiously to 1,789 tons.[26] In 1714 when production must have been at its height the shipment was 2,049 tons.[27] By 1724, however, the trade had declined to 756 tons and in the following year to 668 tons.[28] In 1726 production ceased, and six salt pans were transferred to Blyth. Although by then the sea-salt industry of the north-east coast had passed its zenith, the more immediate cause of the decline of salt-making at Cullercoats was undoubtedly the difficulty of obtaining fuel from the failing colliery nearby.

The mid-century expansion of Hartley Colliery caused an increase in the output of refuse coal and led to the growth of other coal-burning secondary industry at Seaton Sluice. Glass manufacture was begun by Thomas Delaval in 1763, with the construction of a 'glass manufactory . . . a handsome building 220 feet in front, the side walls to the roof 36 feet'.[29] Coal, sand and sea-kelp were available locally, and other necessary materials could be brought cheaply as ballast in returning colliers. Bottles were the main speciality although some earthenware and window glass was made. By the end of the century the regular yearly output of bottles was over 200,000 dozen, nearly all of which were shipped to London.[30] Specialised workmen – blowers, teazers, finishers, founders and the like – were employed, and the Delavals built streets of terraced houses for their accommodation. The making of copperas, a mordant crystallised from iron pyrites mined in association with coal, and some shipbuilding added to the diversity of industry at Seaton Sluice before the end of the century. Thomas Delaval's suggestion that 'we should soon see a large town start up which might almost double the estate'[31] seemed to be justified at the time. His prognostication was not fulfilled, however, for the growing inadequacy of the harbour facilities, the decline of salt and copperas manufacture and of Hartley Colliery, and the end of direct control by the Delavals in 1808 brought decay to the settlement, although the glassworks were operated until 1870.

Pit settlement

During the seventeenth century colliery leases increasingly included the clause that lessees should have 'liberty to erect . . . such house or houses, hovel or hovels, lodges or sheds . . . as shall be needful'.[82] Before then, pitmen in Northumberland had been forced to find accommodation in existing towns and villages within walking distance of their places of work or to squat in temporary shelters on commons, village greens or waste ground. This situation prevailed in the first half of the seventeenth century when seasonal labour from the rural areas of Northumberland and the Border was largely used in mining.

As mining operations increased in scale and continuity, the advantages of a permanent workforce residing near the colliery became evident, and the first rudely-built groups of pitmen's cottages began to appear. Such a settlement developed within the sharp bend of Whitley wagonway as it entered Monkseaton Estate in the years following the opening of Whitley and Monkseaton Collieries. It probably accommodated migrant labour from the areas where collieries were declining. A similar development took place at Goldenhole which seems to have sprung up as a daughter settlement to the main pit village of Hartley, and Earsdon Parish Registers record pitmen living at 'Goudine Hole' by the middle of the eighteenth century. Both these mining hamlets seem to have grown and decayed in accordance with the waxing and waning of the colliery.

Hartley was the original nucleus of the manor of Hartley, but by 1610 Sir Robert Delaval had enclosed the open fields and evicted the leasehold tenants of the manor, after which its inhabitants seem to have turned to fishing, salt-making and coal-mining for their livelihood. Parish registers show that pitmen and a few fishermen continued to dominate the occupational structure of the settlement into the nineteenth century.[83] Very few pitmen lived at Seaton Sluice which was inhabited mainly by seamen and those employed by its industries. The terraces there were of two-storey houses (Fig. 2), each accommodating two families.

Conclusion

Today, remarkably little remains of such diverse and far-reaching industrial change. The only remnant of the industries of Cullercoats and Whitley is the old pier, much repaired, but some old masonry is still visible. Everything else has been submerged by the growth of Whitley Bay. The decayed harbour installations at Seaton Sluice are the most impressive legacy. Here the visual testimony to past industrial activity and the scale of 'New Cut' in its historical context show how considerable was the human achievement, even though the piers at both entrances to the harbour have been demolished by the sea. The remains of the eighteenth-century residential area and of the glassworks have been almost completely obliterated by later developments,

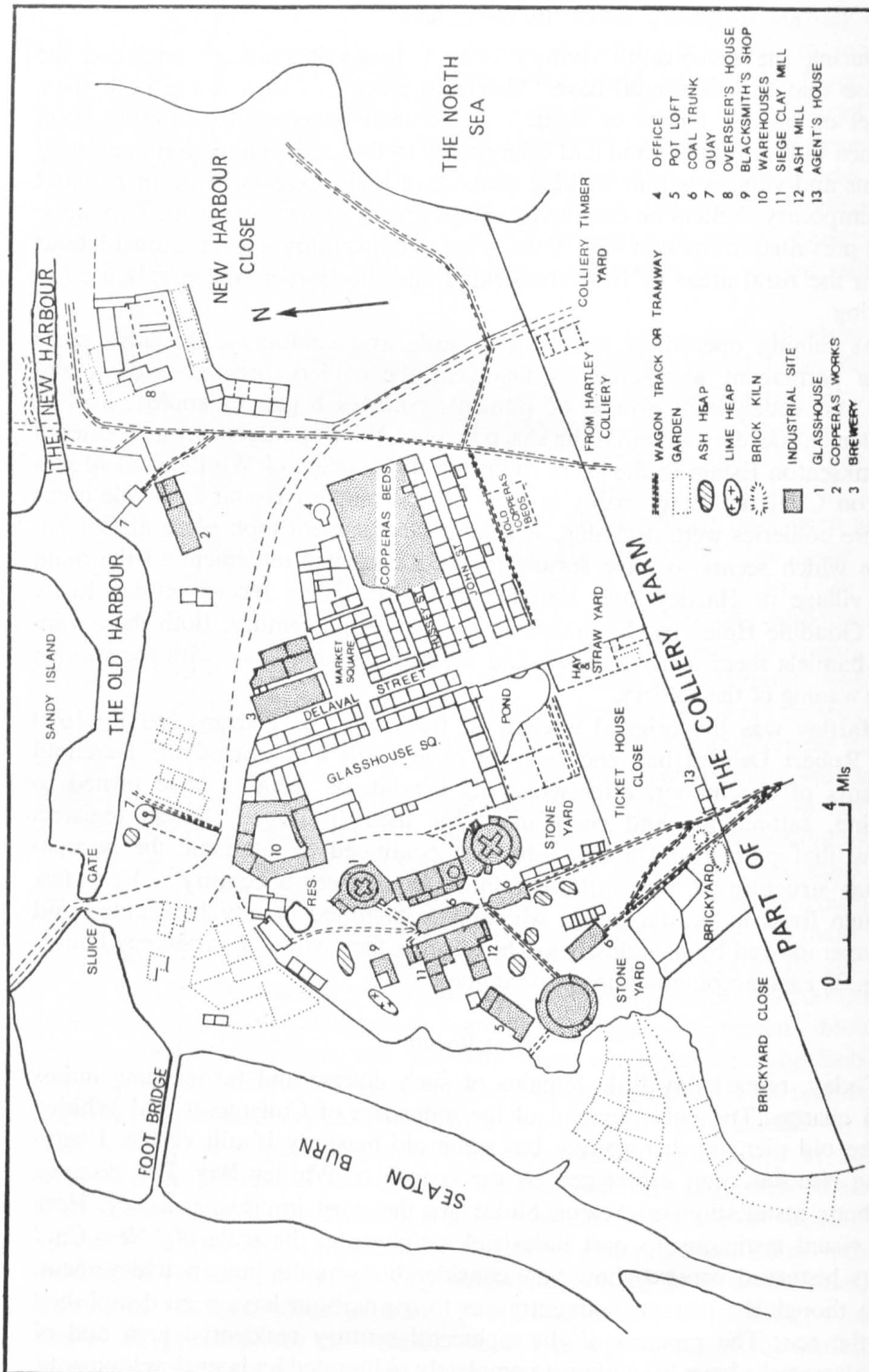


Fig. 2 Seaton Sluice in 1812
(From a plan in the Northumberland County Record Office)

and especially by twentieth-century speculative housing schemes, save for a few remnants of stone walls, an ash heap and scatterings of furnace slag. Only the Octagon (4 on Fig. 2) of the settlement fabric of the eighteenth century remains intact. Hillocks rising out of the fields of South Hartley Farm correspond roughly to old pitheads of the colliery but even these are difficult to distinguish.

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