The origins and treatment of derelict land in County Durham

DEREK HARTLEY

The University of Durham
Department of Geological Sciences
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ABSTRACT

The study considers the programme of derelict land reclamation carried out in County Durham, which was largely dictated by considerations of economic development and visual impact. The origins of derelict land are however widespread and were originally related to the sources of raw materials. The geological background to mineral recovery in the county is therefore examined as this strongly influenced the extent and pattern of industrial development which subsequently became derelict.

County Durham has, to a large extent, been dominated by coal. Records of past mining are examined and compared with those for derelict and reclaimed land. The nature of potential problems is assessed and categorised, noting especially the particular case of coke products and the impact of opencast mining. The same basic procedure is then followed for other minerals such as iron and vein minerals including lead. Surface extraction of clay and rock is considered in conjunction with the problems of waste disposal.

Having looked at the origins, distribution, history and problems of suspect sites, the nature of the risk is assessed using recommended procedures, including verification of on-site conditions. Sites are then reviewed, in the light of government policy, to determine the need or otherwise for further examination or treatment. Consideration is given to pollution standards and other influences which may affect future policy.

Conclusions are finally drawn on the effectiveness of the methodology used in this study and recommendations are given for further evaluation to ensure compliance with current standards. These include broad screening exercises leading in some cases to detailed investigations. Revision of records to enable easy analysis, should future legislation require this, would be a logical next step.

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1.0 INTRODUCTION

1.1 History

Successive attempts have been made in Great Britain to modernise, and make viable, an economy and social fabric shaped in the 19th. century and earlier. These have, in the past, been hindered however by a legacy of "old thinking" and attitudes to work which led to the belief that there is a "proper place" for industrial trades (Warren, 1976).

Originally, industrial location decisions were related to geology and depended to a large extent on the location of raw materials, rarely taking account of any wider perspective. During the industrial revolution this attitude changed in County Durham (Fig.1.1), as elsewhere, and attention was transferred to flows and relationships between districts although production sources remained generally fixed. By the time the extensive restructuring of the late 20th. century took place, however, retention of the distinctive characteristics of County Durham was felt to be less important and the objective became that of creating an inter-regional likeness. This would establish a "level playing field" for redevelopment which required the removal of past signs of heavy industry. It was primarily this large scale relocation which caused so much dereliction and placed a greater emphasis on that already created, leading to the subsequent reclamation programme.

The incidence of dereliction can therefore be related to the geological conditions in the county, the sequence in which development occurred, and the manner in which it was later abandoned, due to exhaustion or for economic reasons. Coal, iron, vein ores and other mineral workings all influenced the pattern, either individually or in combination.

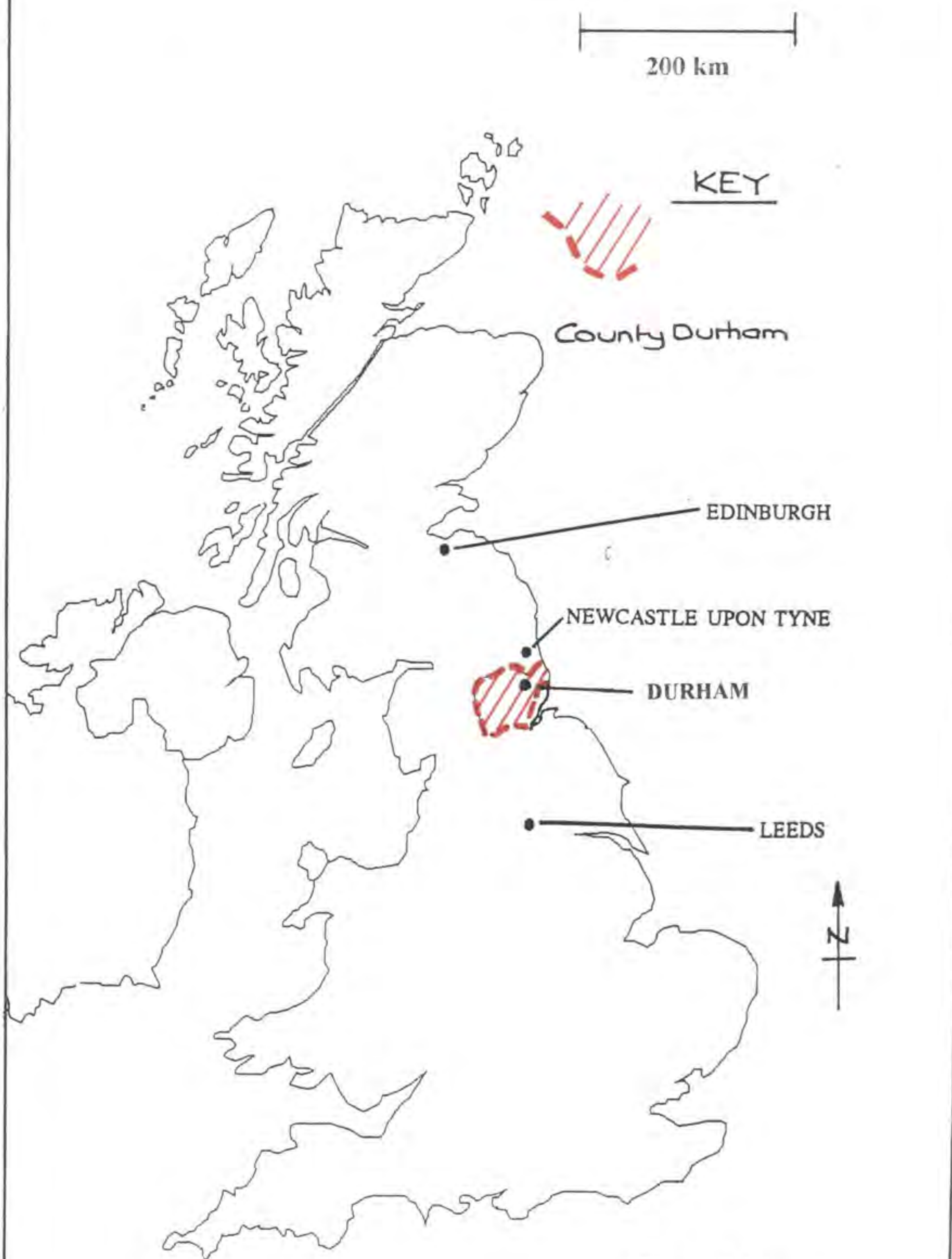


Figure 1.1
Location Plan - County Durham

It was against this background that the reclamation policy in County Durham was developed, initially by the County Council.

1.2 Past Reclamation

Although experiments into ways of reclaiming derelict land had taken place in Durham in the 1930's and a number of unreshaped pit heaps were planted with trees in the 1950's, a serious programme of reclamation was not instigated until the Government established a grant regime to assist the process. This began in 1960 at a rate of 50% of the defined eligible costs of reclamation treatment, was raised to 85% in 1963 and finally increased to 100% in 1976, although lower rates applied in parts of the country not classed as Development Areas (Hartley, 1984). A further incentive to the programme was provided by the disastrous tip slide at Aberfan in South Wales on the 21st.October 1966. Before this event, which resulted in enormous loss of life, few colliery spoil heaps were constructed with any attention to the normal standards of civil engineering design (McKechnie, 1972). As a result of this the treatment of abandoned mines was re-examined and mandatory procedures for the control of both spoil heaps and lagoons, were established, superseding the 1954 Mines and Quarries Act which had controlled the working of mines until that date and had been shown to be deficient in many ways, concentrating as it did on production matters. The science of Soil Mechanics was growing in influence at this time and parameters were determined for pit heap construction, allowing a rational design procedure to be established, which had not previously been considered.

The legislation in the Mines and Quarries (Tips) Act, 1969 which was brought into being was a two part provision. The first section covered the management of existing mines and quarries by the Mines and Quarries Inspectorate, and the second part, although not mandatory, allowed local authorities to ensure disused pit heaps did not constitute a danger by reason of instability.

The Government asked for a national derelict land survey and local authorities began to assemble multi-disciplinary teams. It was at this time that the definition of derelict land was established as: "land so damaged by industrial or other developments that it is incapable of further beneficial use without treatment" (DoE,1989). The categories of derelict land were very broad and set the pattern used in the first derelict land survey in 1974 and repeated in 1982.

In Durham the reclamation policy which developed was naturally dominated by the coal industry from which so much of the visible dereliction had stemmed. The priorities were determined by economic development criteria, principally concentrating on the main transport corridors, and by landscape considerations which took into account specified areas of high amenity value. The intention was to assist the attraction of new industry to the county and, despite the new legislation, it is not certain that safety or pollution constituted a major consideration in planning the programme of works, which was in any event greatly influenced by the process of land acquisition. In 1970, at a Civic Trust Conference, a target of 10 years was set to reclaim the major areas of derelict land and this was endorsed by central government. Lord Robens, on behalf of the National Coal Board, agreed to assist by releasing land to local authorities and this naturally led to a concentration on NCB sites.

In time a slight reduction occurred in the number of waste heaps, despite continuing colliery closures, reflecting the success of this aspect of the derelict land programme (Fig.1.2). Nationally the proportion of derelict land consisting of waste heaps reduced gradually from 27% in 1974 to 23% in 1993. Government policy had already begun to recognise this and from 1981 the concept of Category "A" schemes was introduced which placed greater emphasis on industrial, commercial or housing development known as "hard end use" (Hartley, 1984). The categories of derelict land became more detailed and

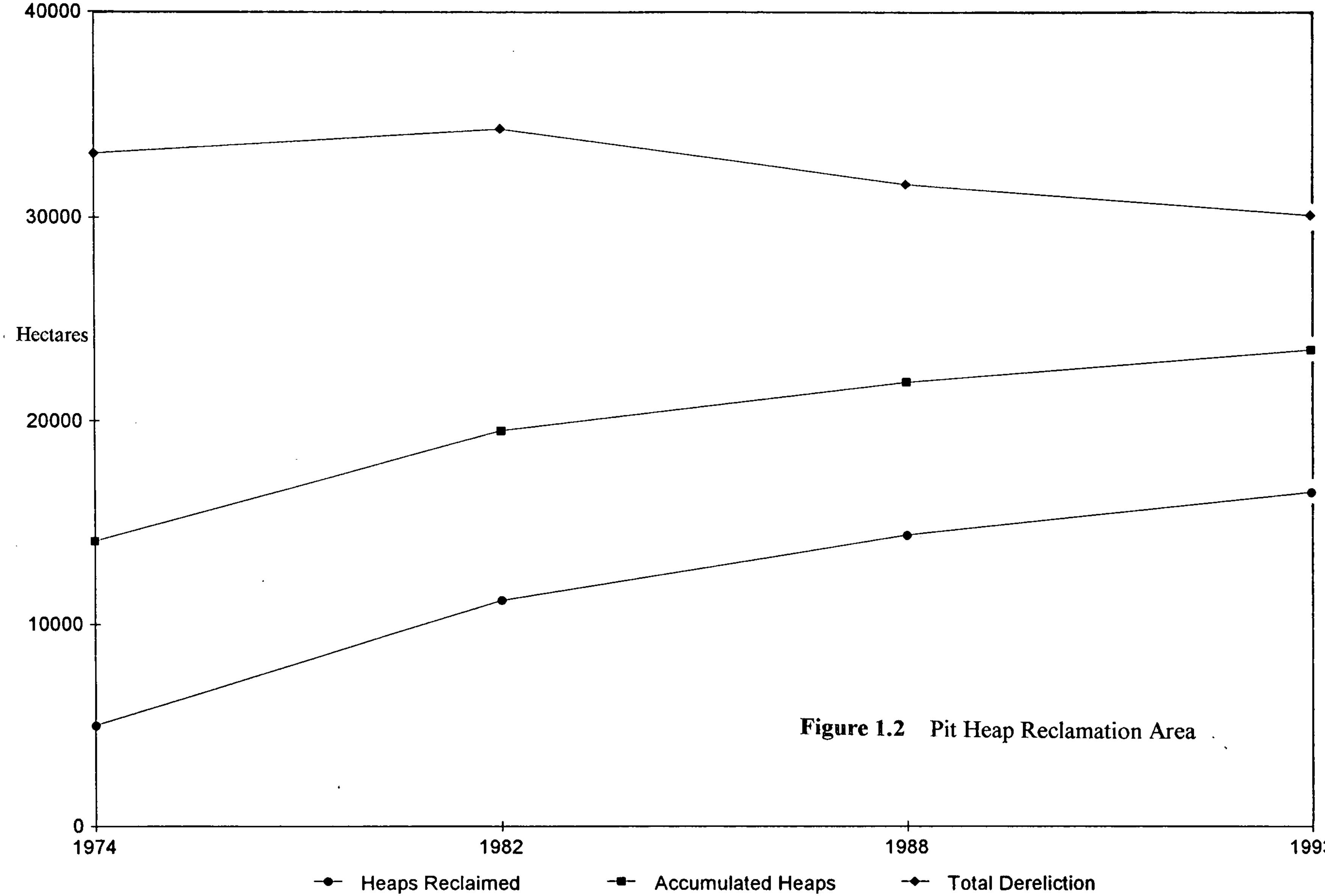


Figure 1.2 Pit Heap Reclamation Area

attention was progressively transferred to contaminated or inner city sites. In County Durham the predominance of pit heap reclamation schemes also reduced and from 1987 to 1991 "other" reclamation constituted the bulk of the work. Following another phase of colliery closures, the situation reverted to the earlier pattern and the reclamation programme in the county again reflected the preponderance of colliery spoil heaps as the main target. County Durham was never ideally suited to the emphasis placed on "hard end use", given its pattern of widely spread settlements and the location of the extractive industries in relation to these. Environmental improvement and landscape considerations continued therefore to dominate policy as they had done for many years. Dereliction caused by the coal mining industry was generally well covered but the special characteristics of cokeworks sites and potential problems caused by other minerals were less well addressed.

1.3 Current Policy

Current thinking in the treatment of derelict and contaminated land takes a very different approach. The first step should always be a desk study of previous uses of the land followed by an initial site appraisal and limited site examination. Depending on the initial findings a more extensive survey together with geotechnical and chemical analysis may be required. In this way a comprehensive picture of the site can be built up and appropriate treatment provided taking into account the inherent risk to life or property. Government records and the Department of the Environment publication "A Review of Derelict Land Policy 1989" identified areas of weakness in their database and areas requiring research. The deficiencies involved the processes by which land becomes derelict, together with a review of practice, and research was proposed into methods of treatment. It was intended to lead to an examination of the effectiveness of past work and an assessment of the real extent of dereliction, but this has not been carried out in any systematic way and the deficiencies remain.

1.4 Study Content

This study addresses the extent of dereliction in the current administrative County of Durham and provides in the form of a desk study and initial site appraisal, an overview of the effectiveness of work carried out to date. The geological basis for mineral extraction, and the works resulting from this are first examined for the main materials. These are then compared with records of reclamation schemes which have been carried out. Possible problems which are related to each mineral or process are identified and a preliminary risk assessment carried out. Following a description of current policy for the treatment of derelict and contaminated land, a preliminary view is established of the need for further treatment, with typical areas being examined in more depth and verified on site. After a review of policy, taking into account other considerations, recommendations are given for a revised approach to investigation and treatment. Consideration is not given to industrial sites which may have caused dereliction due to processes unrelated to primary production.

2.0 THE DURHAM COALFIELD

2.1 Geology

The Durham Coalfield forms part of the Upper Carboniferous (Westphalian) stage, extending in a belt across Europe from Great Britain, through northern France and Belgium, to the Ruhr and beyond. The coalfields of Scotland and the extreme north of England differ from the fields immediately to the south, having been formed towards the margins of a major basin resulting from crustal subsidence on the Carboniferous shelf (Anderton, Bridges, Leeder and Selwood, 1979). This has influenced the pattern of coal mining in County Durham. The basement surface on which sedimentation commenced was made up of structurally contrasting blocks and troughs. The blocks, consisting of pre-Carboniferous intrusions, of which the dominant one of interest in this area is the Alston block, were less dense and consequently more buoyant and resistant to subsidence than adjoining areas of the crust (Fig. 2.1).

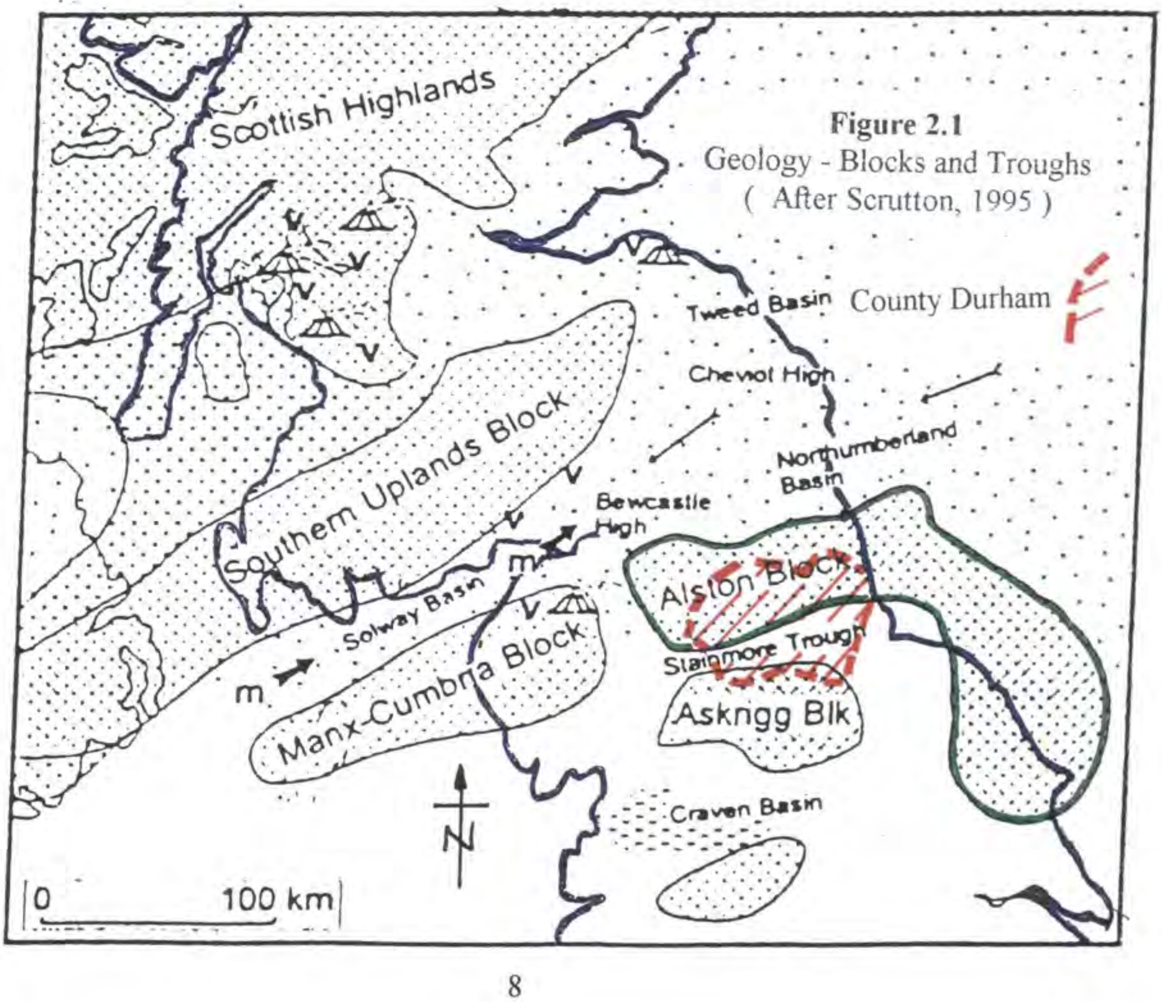


Figure 2.1
Geology - Blocks and Troughs
(After Scrutton, 1995)

This elevated structure, forming initially land and later a shallower zone in the Carboniferous Sea, influenced deposition even when it was submerged and engulfed by later sediments. As well as resulting in the sequence of strata laid down being thinner than "time-equivalents" in the troughs, the differential subsidence explains the total thickness of strata being less than the maximum for the whole Central Pennine basin, which is found in the vicinity of Manchester (IGS, 1971). There is little doubt that the Coal Measures were laid down as a thick but discontinuous sheet of sediment, derived from erosion of the Caledonian landmass to the north, which accumulated in this broad basin covering the whole of northern England.

Cyclic or rhythmic sequences, or cyclothems which characterise the coal measures, began with an abrupt change of sea level, giving marine or near marine conditions (Fig. 2.2).

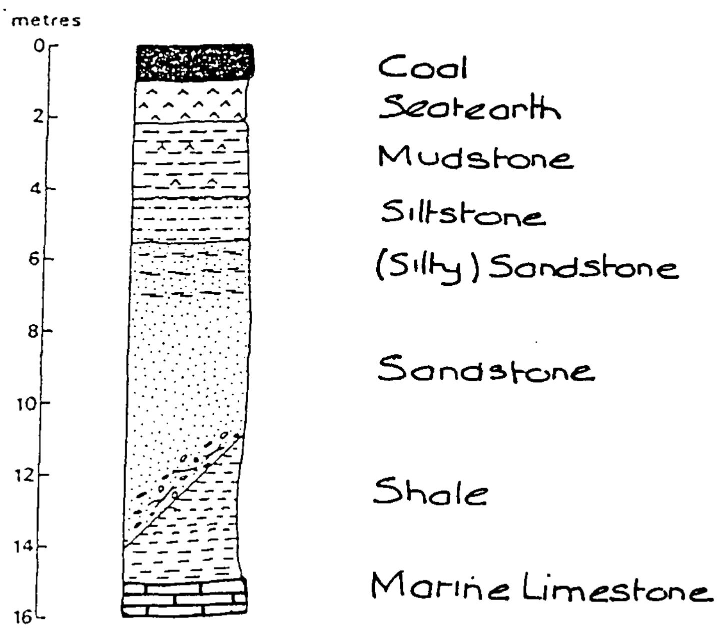


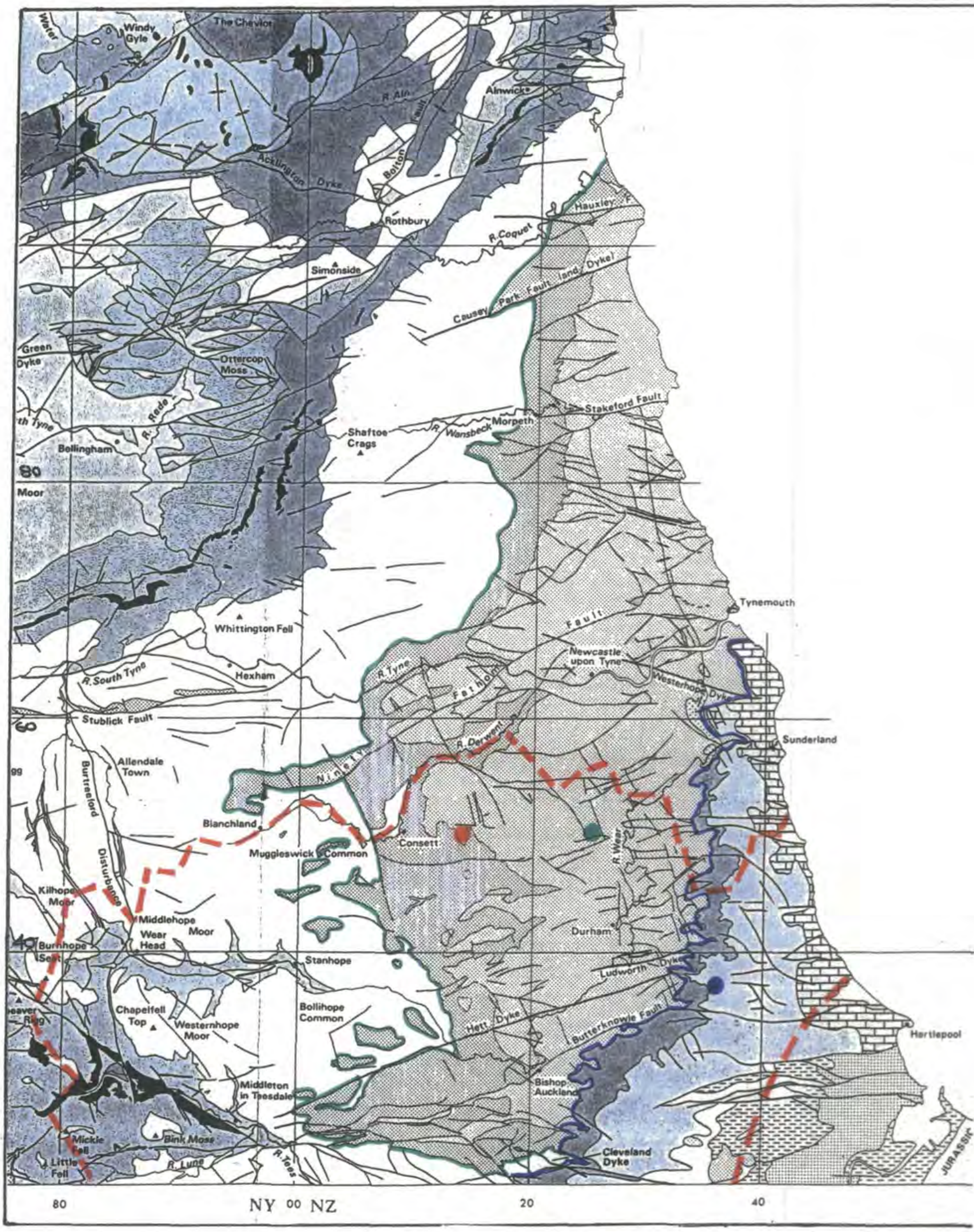
Figure 2.2
Coal Cyclothem

In general the cycles consisted of marine limestone followed by a cacareous shale, ferruginous shale, silty shale, shaley sandstone, seat earth or ganister and finally, coal. In Coal Measures times truly marine invasions were infrequent and periods of coal formation were longer. Since sedimentation more or less kept pace with subsidence, the result was a series of deltaic strata containing many coals of workable thickness, as the sequence has been repeated many times due to this more or less random combination of subsidence, sedimentation, channel formation and marine incursions.

A period of uplift and tilting followed, caused by the compressional effects of the Variscan orogeny to the south (Scrutton, 1995). Subsequent erosion and weathering resulted in seams outcropping in the west of County Durham which, with the dip to the east, affected the timing and extent of mining in different areas.

2.2 Coal Measures

The western edge of the Coal Measures outcrop, resulting from this process, is an indented line extending from Amble on the Northumberland coast to Barnard Castle in the south of County Durham. The measures dip to the east where they are concealed under the overlying Permian strata before continuing under the North Sea (Fig. 2.3). Productive coals in County Durham are concentrated in the Lower and Middle Coal Measures, the Upper Coal Measures and other sediments having been largely eroded prior to the Permian strata deposition. The Upper Limestone Group of the Dinantian or Lower Namurian strata, which can contain coals, is barren of coal in this area apart from the poor 0.45 m Oakwood coal in Upper Weardale and an inferior seam, known as the Winston, near Barnard Castle. Deep boreholes at Crook and Chopwell, which were



Edge of Coal — Iveston ●

Permian Limestone — Waldridge ●

County Boundary - - - East Hetton ●

Figure 2.3 Northumberland and Durham primarily drilled to investigate the deep granite intrusion, failed to prove any seams of importance (Trueman, 1954).

Within the Coal Measures the Lower or Ganister group has a few unimportant coals and only two seams, the Victoria and Marshall Green, have been worked extensively. The Middle or main productive group contains all the best coals. The Upper group has limited coals in the north and north east, now outside the present boundary of the county. These seams tend to thin to the east, becoming arenaceous and may indeed die out.

Individual seams also gradually change in character from west to east, having progressively higher proportions of volatile constituents and thus diminishing suitability as coking coals which require a high strength and low percentages of the volatile constituents which have to be expelled during the coking process. A major influence on this is the higher geothermal gradient, or rise of temperature with depth, above the Alston Block where higher temperatures have served to expel water and volatile constituents. The rank, or degree of maturity of coal from peat to anthracite, also increases with depth, due to higher temperatures, in accordance with Hilt's law which states - "*In a vertical sequence, at any one locality in a coalfield, the rank of the coal seams rises with increasing depth*" (Hilt, 1873). The rate of increase, or rank gradient is dependent on the geothermal gradient and heat conductivity of the rocks. Thus in east Durham the coals were mainly used for gas and steam purposes. Coal rank can, however, be affected locally by igneous intrusions which have thermally metamorphosed the seam. The effect of the Carboniferous quartz dolerite dykes is more pronounced than the tholeiites, or Tertiary intrusions, and in the case of the Ludworth dyke has produced a wide band of alteration which affected the preferred working of the coastal collieries (Jones and Magraw, 1980). In South Durham, due to the varying conditions, all uses were possible, and both gas/steam and coking coals were produced.

The coalfield is traversed by a number of faults which complicate working and, as in the case of the large Butterknowle basement fault, running to the coast from Lunedale, terminate many seams. Pre-glacial valleys infilled with drift materials and areas of coal left as protection against underground flooding, or where surface settlement would be unacceptable, have also reduced the capacity for continuous working.

The extent and pattern of coal working in County Durham can therefore be related to the geological formation of the coalfield and the consequent variations in works have also affected the type of related industry, the nature of dereliction and the timing of its occurrence.

2.3 Mining History

Although there is evidence to suggest that the Romans in the region used coal for fuel, contemporary records indicate that it was not until the 13th. century that underground mining was carried out to any extent. Due to the ease of access and the limited need for excavation, the first pits were along the Tyne, and then the Wear, and the coal was simply won by exposing the seam at the surface and working along the outcrop, or by bellpits in which a shaft was sunk through the surface cover and widened out in the coal seam (Anon, 1992). As they were enlarged these excavations would become unsafe so new pits would be opened out and in time the old pit would collapse. The lateral extent underground was limited and groups of these pits are often found, following the outcrop. Spoil from a new pit would sometimes be used to backfill the previous working. At depths greater than 6m (20 ft.) the method became impractical and radial tunnels were headed out into the seam from the shaft but these were limited by transport difficulties and reliance on natural ventilation. Mines were worked with the dip or to the dip with drainage outlets. Little support was used and remnant pillars would be left unworked to retain the roof but these would often only survive for the limited life of the mine. During the 16th. century, restrictions on the use of timber for fuel and increases in exports, particularly to France, led to a growth in production. From the late 17th. century better mechanical appliances for pumping and improved methods of removing coal were developed and a system of roads and pillars was used which was a pre-cursor of the later pillar and stall, or locally, bord and pillar working (Fig.2.4).

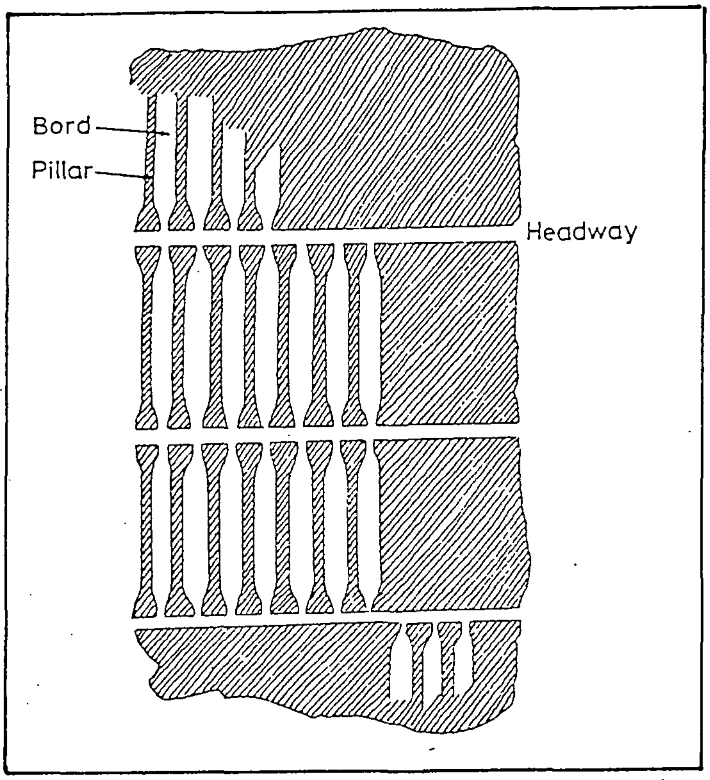


Fig. 2.4 Bord and Pillar Working

The first industrial revolution in the second half of the 18th. century resulted in further growth but, although pumping was developing, extractive methods were still limited and by 1780 the riverside and shallow seams were running out. By the 19th.century there were real fears of exhaustion but new reserves were discovered in South West Durham and mine owners began switching their attention from one part of the coalfield to another in search of economic recovery (Sturgess, 1981). The Workings began to extend across the county and the scale of operations also increased.

By the 1820's mining in the Bishop Auckland area, which had previously depended on small pits at shallow depths, expanded as a result of capital investment seeking to develop new discoveries of iron ore deposits, access to which was made practicable by the construction of the first railways (Anon,1992). The large holdings of the Pease family for example utilised over 70% of their coal output for ironmaking. Similar processes were occurring in the old mining areas of North West Durham where new reserves were accessed by rail and diversified into new outlets, thus removing dependence on the London household market. The increase in scale of these operations resulted in concentrations of ownership, due to the need for capital outlay and the efficiency only to be obtained in large collieries.Investment by business consortia succeeded in overcoming the previous difficulties of raising water fast enough to keep pits dry below 110 metres (360 ft), and this was complemented by improvements in underground haulage systems and support of roadways. Whereas previously it had been cheaper to open up a new shallow pit rather than pursue coal laterally below ground, owners could now win coal over a wide area from a single "mother" pit (Sturgess, 1981). This of course resulted in far fewer collieries in the East of the county, where development was now taking place, compared to the West and created the opportunity to recover coal from below the Permian limestone cap which was first done by the sinking of the Hetton shaft in 1822 (Fig.2.3).

After 1850 the bord and pillar method of working, which only allowed 40% recovery, was finally abandoned, having been progressively reduced since about 1790. Collieries also concentrated on specific ranges of coal and their life extended to a minimum of twenty five years although problems still remained with the difficulties of working thin seams. Diversification of markets continued and by 1870 the proportion of coal used for coke had increased to 36% and for gas to 22% (Sturgess, 1981). Exports were increasing and in general new developments were concentrated in new pits along the coast which remained the dominant factor in the Durham coalfield until the pit closures of the 1980's and 1990's.

By 1930 a decline in production had started in the south and west of the county which subsequently spread to other parts of the coalfield. Rationalisation under nationalisation of the coal industry still left 127 pits operated by the National Coal Board in 1948 together with a number of small private mines. By 1974, due natural exhaustion of reserves and a concentration on more productive mines, this number had been reduced to 22. A further factor was the increase in opencast mining since its development in 1943 in the wartime drive to fuel industry (Anon, 1992). Specific markets suffered as the British Steel Corporation built up its import of coking coal to 25% in 1980 and by 1984 the Redcar Steelworks on Teesside was only taking 48,955 tonnes of Durham coking coal as against 2,105,000 tonnes imported.

2.4 Reclamation

The large reclamation programme, when it began in the 1960's, was therefore addressing a coalfield with a limited number of large mines still working in the east of the county with fewer working and many closed mines in the West. The majority of the latter were closed before the establishment of the National Coal Board but records prepared or inherited by the Board identified the extent of working and the presence of shafts or drifts where other details were unknown. Opencasting of the shallow outcropping seams in the west of the county had begun to eliminate dereliction in some areas in a comprehensive manner.

3.0 COLLIERY RECLAMATION AND ABANDONED MINE RECORDS

3.1 Records

3.1.1 National Coal Board Records

Prior to nationalisation, private mine records were incomplete and did not conform to common scales. Boundaries between adjoining areas were therefore difficult to reconcile and, as the records were not standardised, gaps could occur. In the 1950's, the distribution by the Ministry of Power of plans of Abandoned Coal Mines and worked out opencast Coal Mines, and the establishment of a Durham Divisional Mining Records Office, enabled the National Coal Board to issue a new catalogue of the plans relating to the Division which included the County of Durham. Part I contains an alphabetical list of plans on which the N.C.B. records of abandoned mines identify the extent of coal extraction workings referenced by the County sheet blocks on the Imperial 6" to 1 mile Ordnance Survey sheets. These numbered are divided by the O.S. into quarter sheets, coded North East, North West, South East and South West. Part II uses a more detailed referencing system in which the quarter sheets in the N.C.B. system are sub - divided E-W into twelve numbered cells and N-S into eight lettered cells so that each of the original numbered sheets of 6 miles by 4 miles (9660m. by 6440m.) becomes a block of 384 smaller units, each referenced by a unique alpha-numeric code, measuring one quarter of a mile square (400m.). The names of N.C.B. Plans or Mines are listed alphabetically with supplementary information, catalogue number and the quarter sheet reference, up to closures which occurred in 1958. Included are Volumes I and II of the earlier 1928 Catalogue, Supplementary Volumes dated 1930-1939 and Plans deposited 1939 to August 1958. Thereafter records are listed in an Addendum year by year. A typical extract in Part I reads:

Name of Plan or Mine	Name of Pits and Supplementary Information	Cat. No.	Quarter Sheet Reference
Thrislington	Byron, Coke, Edmondsley, Florence, Hawthorn, Little, Oven, Sacriston, Quarry	D.558	35 N.W. 35 N.E. 35 S.W.
Thrislington	See Cornforth West		
Throstle Gill		13496	42 N.W. 42 S.W.

In Part II each numbered quarter sheet is then reproduced in the more detailed form giving the previous data together with the smaller grid map reference, the seam worked and year of abandonment, and a Mine Records Office (M.R.O.) reference. A typical extract reads :

Cat. No.	Name of Plan or Mine	Map Reference	Seam & Year of Abandonment		M.R.O. Ref.
10258	Friends Farm	F 12; G 12	Main	1930	F.12/18
10259	Harperley	H6	Marshall Green	1930	F. 12/20
10375	Low Beechburn No.1 & 2	E11,12; F12	Main	1930	F.13/22

Additional information is provided on the numbered quarter sheets in the form of Locations of Mine Entrances, where no plans are available but a shaft or adit is recorded as being within the reference square quoted. A typical example is :

LOCATION OF MINE ENTRANCE		
Bedburn North	E6; F7	Coal

Shafts and Levels are also listed separately where plan details are not available, and where information has been extracted from Ordnance Survey Maps, with reference to the Parish in which they are situated. These are typically shown as below:

LOCATION OF SHAFTS AND LEVELS		
	A5; B5. Wolsingham Parish (1924)	Coal /Lead Ore

3.1.2 Local Authority Derelict Land Records

Derelict land records, commencing in 1964, were compiled mainly from visual inspection, being heavily influenced by the impact of the dereliction on the main transport corridors in the county including the A1(M) and the East Coast Main Line Railway. Some time later, sites within areas of high landscape value, as defined in County Structure Plans, became a second important category. Early programmes were, of course, determined by the availability of land, primarily from the National Coal Board. Dereliction was put in the categories used in the first national derelict land survey by the Department of the Environment in 1974. These were:-

spoil heaps;

excavations and pits;

military land;

railway land; and

other forms of dereliction.

This format was maintained in 1982, when the derelict land survey was repeated, but modified in 1988. At that time the Spoil heaps category was sub-divided into:-

colliery waste;

metalliferous waste; and

other waste.

Two new categories were introduced of Mining Subsidence, mainly to deal with non-colliery underground workings, and a General Industrial classification. Sites which have been reclaimed by the County Council, District Councils or other Public Departments are given reference numbers and are identified on the Ordnance Survey 6" to 1 mile sheets by number, with the boundary plotted. For ease of location the new National Grid referenced quarter sheet number is also included in the records. Separate schedules list sites within the same categories which have not yet been reclaimed or do not justify being reclaimed.

3.2 Screening

3.2.1 Abandoned mines

Using primarily the County Council's records of reclaimed sites, and N.C.B. publications including a list of closures in County Durham and Northumberland since 1947, a schedule of collieries in County Durham was prepared for this Study. Those reclamation schemes which were linked to coal mining activities were identified and cross checked by name against N.C.B. abandoned mine records. It has to be assumed for this exercise that a record of reclamation indicates adequate treatment of all coal extraction and processing works related to that named mine. It appeared initially that 24 sites were listed which could not be correlated with an abandoned mine. Subsequent examination however showed all of these to have a valid explanation for the apparent discrepancy which was frequently related to the usage of different local place names (Appendix 1). Comparison of the two forms of record is made possible by a transparent overlay of the N.C.B. grid system reduced to the scale of the derelict land records drawings. Far more queries were raised when considering N.C.B. abandoned mine records which did not have an equivalent entry in the derelict land register. A major problem in this respect is again the nomenclature of mines involving the use of duplicate names and local alternatives or adaptations. In the vicinity of Shildon for example, on N.C.B. Sheet 42, a complex of mines demonstrates the difficulty of tracing an individual pit through its name alone (Appendix 2). Notwithstanding the above, screening of the N.C.B. records in this way against listed reclamation sites eliminates a large proportion of the abandoned mines, but leaves a significant number unexplained. There are variations across the coalfield and, as the numbers of apparently unreclaimed mines within the numbered quarter sheets shows significant concentrations within certain areas of the coalfield, the reasons for this merit further consideration (Fig.3.1).

Mines in the extreme west of the coalfield were on the outcrop and consequently were worked very early and on a small scale with records of some of these workings perhaps being incomplete. In the east of the coalfield , mines were opened post 1826 in the era of large pits and they were therefore fewer in number, more easily identifiable and the obvious targets of the large reclamation programme when closure occurred. In the centre of the coalfield it could be expected that neither of the above scenarios would be dominant. Some mines were worked relatively early in the life of the industry with the records of these being vague and not easy to trace. Others were worked later and were comprehensively recorded. Figure 3.1 shows the incidence of apparently unreclaimed sites and an East-West section through Sheets 40-44 demonstrates a consistent decrease in the number of mines, unadjusted for the impact of opencasting. The same pattern is generally repeated in the two sections

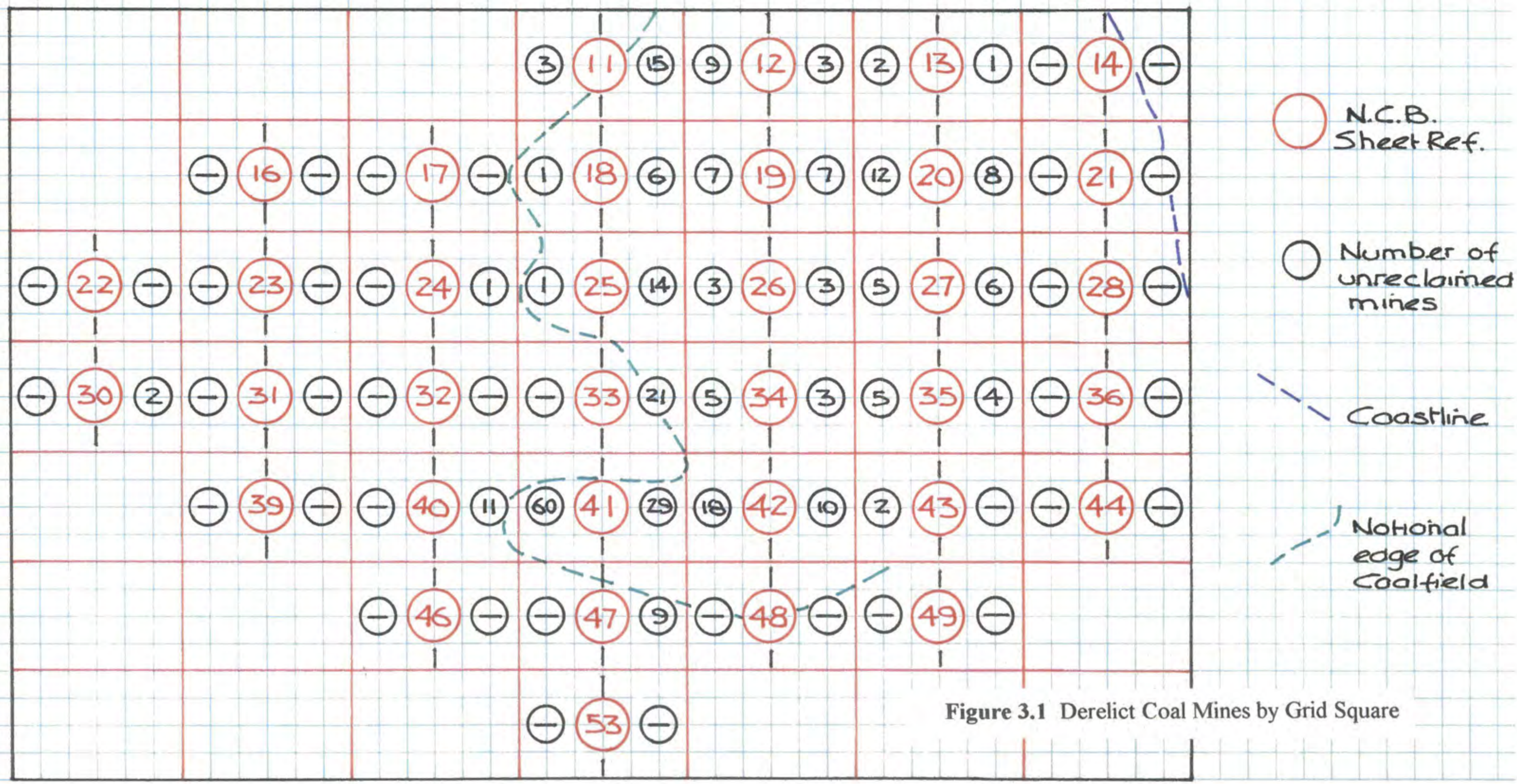


Figure 3.1 Derelict Coal Mines by Grid Square

to the north, but inconsistencies appear on the section through Sheets 18-21. The increase in unreclaimed sites reflects in broad terms the sequence of development in the coalfield and the early concentration on mining along the Wear valley. Sheet 41 also shows evidence of the move to the south west corner of the coalfield at the end of the 18th. century.

3.2.2 Opencasting

A major factor influencing the presence or otherwise of unreclaimed coal workings is the incidence of opencasting. The economic viability of opencasting depends upon the ratio of overburden to coal or, in other words the amount of rock and superficial deposits which have to be excavated and replaced in order to extract each tonne of coal. As the coal seams dip to the east these ratios tend to increase and the extent of opencast mining therefore reduces, thus increasing the numbers of abandoned mines which are likely to remain a problem, if not included in a reclamation programme. Superimposing of part of the County Council records showing opencasting up to 1995 (Fig.3.2), demonstrates the impact of this activity on part of the western area of the coalfield. Sheet 33 has approximately 27% of the total land area, within the exposed coalfield, which has been affected by opencast workings. An indication of the pattern can be established from the comprehensive NCB records up to 1979 which show, for example, the proportion on the adjacent Sheet 34 to the east, reducing to 12%. The effect further east is even more pronounced with areas in the centre of the county having little or no opencasting.

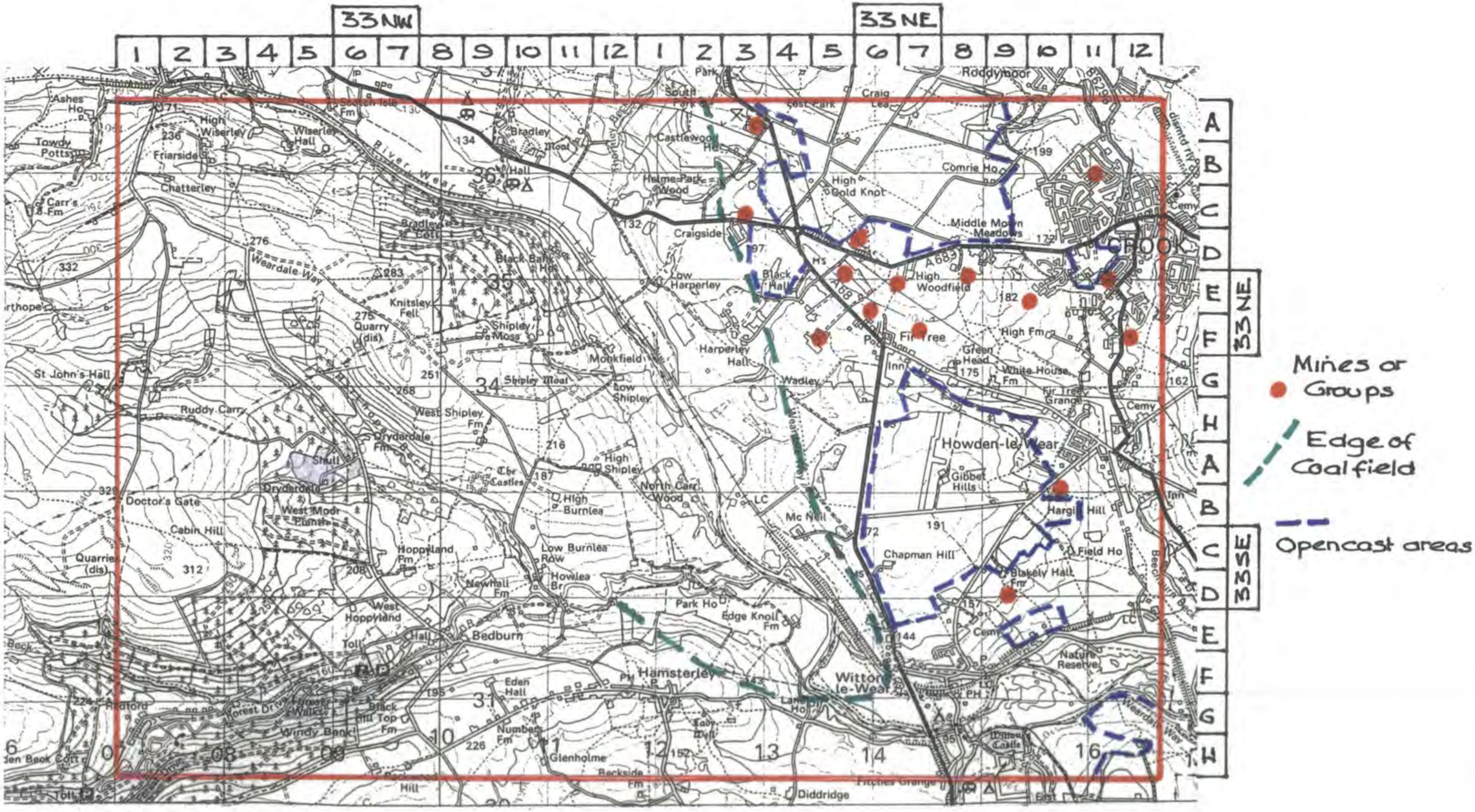


Figure 3.2 Coal Mines - OS Sheet 33

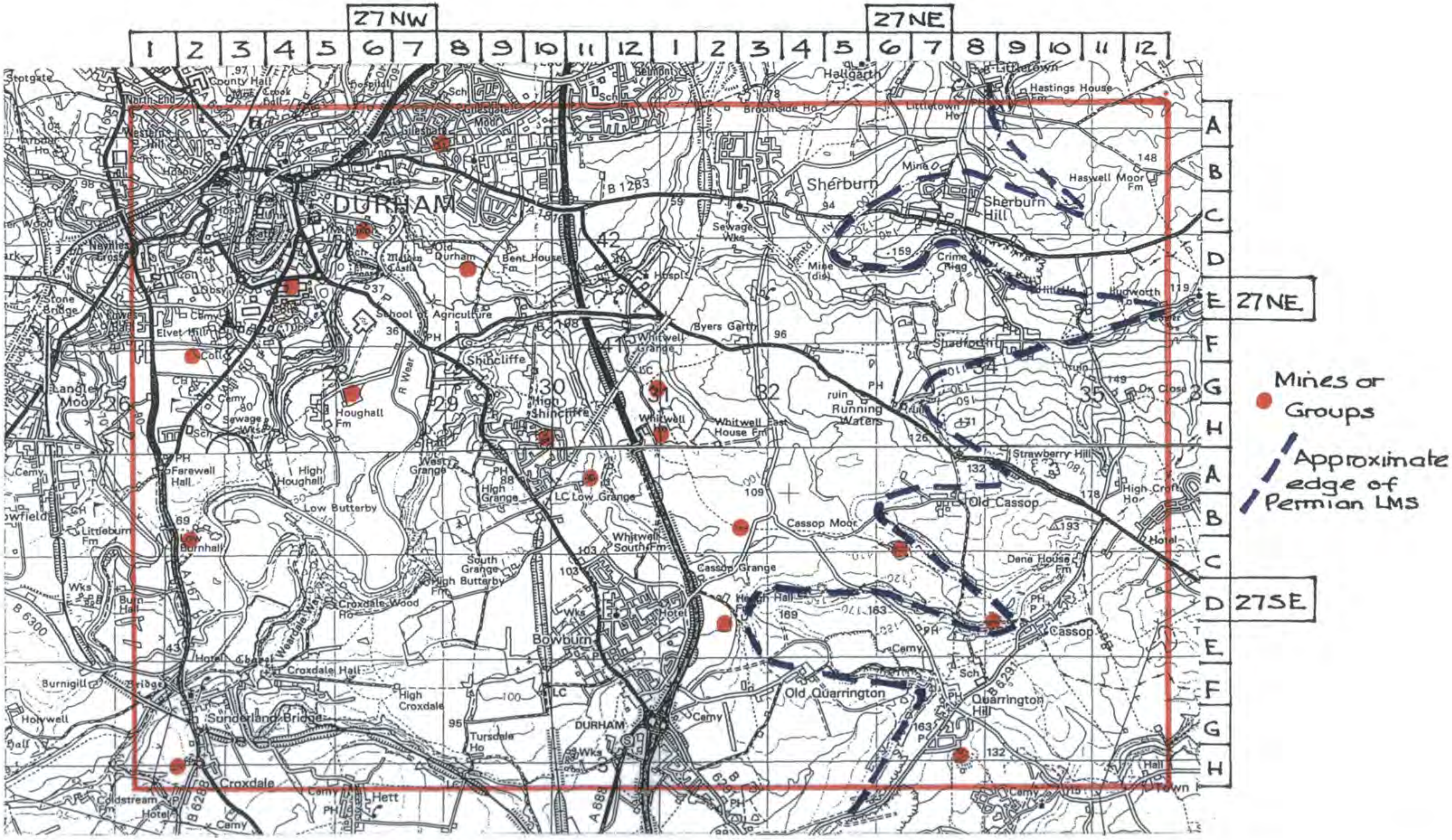


Figure 3.3 Coal Mines - OS Sheet 27

3.2.3 Analysis

In view of the large numbers of mines involved, two pilot sheets were selected for further analysis which were considered to be representative of the different areas of the coalfield. Sheet 33 is typical of the western areas whereas Sheet 27 represents typical eastern conditions (Figs. 3.2, 3.3).

(a) Results - Sheet 33. Initial screening, by name alone, of Sheet 33 produced twenty one mines not apparently treated, of which eight were subsequently found to be within opencast areas. Plots of the alphanumeric zone of interest for each mine showed, in a coarse way, the likely areas where unreclaimed coal mine workings could be suspected. One colliery was included in the local authority schedule of derelict land not justifying reclamation. In addition three areas of working, related to the Shafts and Levels entries by Parish in the N.C.B. records, were apparent on the old O.S. sheets (Appendix 3) when these were examined. In general it was found that few details were discovered from large scale early O.S. maps which were not recorded on the 6" version and for this initial screening therefore the smaller scale search could be quicker and sufficiently accurate. Succeeding, more detailed inspections may justify use of the larger scale and ultimately mine record drawings.

Each of these mines had to be examined to determine if in fact the dereliction still existed on the ground or if adequate reclamation had been undertaken but not recorded.

(b) Results - Sheet 27. A similar screening of Sheet 27 suggested eleven more mines not apparently treated in the reclamation programme and none of these were subsequently identified from County Council records as having been opencasted. All the listed mines, and three shafts or levels shown in the Parish records section, were identified on early O.S. maps. Further inspection brought to light three additional mines or related shafts which had not been disclosed by the initial search. Only one of the Parish record sites, at Hett, was within an area of opencast and none of the remainder were listed as being either due for treatment or in a category not justifying treatment (Appendix 4). As with the sites on Sheet 33, further examination of on-site conditions is required to assess the actual conditions prevailing and the risk involved.

4.0 COAL MINING AND PROCESSING - POTENTIAL PROBLEMS

4.1 Importance of problems

The three considerations of visual intrusion, physical difficulty or danger, and environmental pollution have had very different levels of importance attached to them in reclamation policy to date.

4.2 Nature of problems

4.2.1 Visual Effects

Visual impact has been an integral part of the establishment of priorities and the enormously enhanced image of the County caused by its improved appearance bears testimony to the success of the programme carried out. Surface structures including pit headgear, coal preparation plant and ancillary buildings can be dealt with as conventional demolition work although care has to be taken with sub-surface elements. It is necessary for those carrying out the investigation initially to fully understand the layout including such matters as secondary air shafts and ventilation systems. The removal of the unsightly relics of coal mining at the surface deals concurrently with such associated problems as dust and fly-tipping, and normally, provided the reclamation is comprehensive, other difficulties which are potentially present in waste heaps.

4.2.2 Heaps

Colliery pit heaps can contain not only the minestone residue of the coal washing process but also slurry lagoons on the surface or at depth, and the minestone itself can have inherent problems other than that of instability. Methods of placing discard, using modern earthmoving machinery resulted, in more recent heaps, in better compaction and hence strength, than in the old end tipped system using plant known as the Maclane tippler. Belt conveyors complemented by dozers also produced more stable heaps but in each case other difficulties remained. The process of coal recovery by "washing" or flotation separation results in the production of a fine discard or slurry. Traditionally this was disposed of in a lagoon on, or adjacent to, the heap where it could sometimes be subsequently covered as tipping continued and spread laterally. Slurries, with a high moisture content and low strength, can cause unstable conditions to develop and superficial landscaping without adequate investigation would miss this. The relatively inefficient "washing" of coal also resulted for many years in a discard containing appreciable contents of combustible material. This provided the opportunity in later years for economical reclamation, funded by the proceeds of secondary coal recovery as washing plant efficiencies improved, and it was a viable operation to rewash old heaps containing in excess of 9-10% coal. Initially, however, it left many heaps with the potential to catch fire as exothermic reactions in the constituent materials of the heap, combined with heat development due to friction and pressure, could cause the tip to ignite with potentially disastrous consequences. The formation of unseen voids below the surface as well as toxic fumes given off from the combustion created difficult and dangerous conditions for maintenance, or for reclamation of the heap, which would have to be carried out by excavating and cooling the hot material before blending with cool waste and compacting to prevent air ingress. The minor chemical constituents of the waste tips also cause a further problem, which is that of acid drainage (Pulford 1991). Coal measures are formed under highly reduced conditions, which lead to the formation of sulphide, usually in the form of pyrite. This is stable until exposed to air and percolating water in an unsaturated zone, when it oxidises to form sulphate ions. This is then bacterially catalysed and oxidised under aerobic conditions resulting in hydrolysis and the deposition of iron oxyhydroxides or ochres, which also leaches out other metals by adsorption or co-precipitation. The potential surface expression is therefore a combination of acid waters and staining with the possible addition of heavy metals in the drainage. The efficiency of field drainage can be seriously affected. Changes in groundwater regimes or disturbance of material can result in the occurrence of these conditions which are difficult to control and of long duration. An example of this came dramatically to the world's attention at the former Wheal Jane tin mine in Cornwall in 1992. The failure of a plug holding back groundwater, which had been rising in the mine as a consequence of the cessation of pumping, resulted in the release of a highly acidic toxic orange plume, affecting nearby rivers and spreading into Falmouth Bay. Extensive treatment measures, taking over two years to plan and construct, are still in place and are the subject of long term monitoring. Because of the combination of metals involved, a multi-stage process is required including lime dosing, organic filters containing straw, cattle manure and sawdust, with reedbeds and a rock filter intended to generate algal growth for the final removal of manganese.

4.2.3 Gas

In addition to acid mine drainage, the problem of gas, which is of course a hazard during mining, can be a residual danger in old mine workings, causing asphyxiation or explosions in the same way. Methane gas is given off naturally from some coal measures when the pressure on them is released, and traditional names of "firedamp" and "blackdamp" are used respectively for the mine gases where the composition is predominantly methane, or mixed with carbon dioxide. As with acid drainage, changes in pumping regimes and groundwater conditions can lead to movements resulting in emissions of gas, as can changes in atmospheric pressure.

4.2.4 Shafts and Drifts

One of the major problems of former collieries is the presence of shafts and drifts which have to be made safe and these can exist even where little visible evidence of coal mining remains. Vertical shafts have increased in size generally in proportion to depth of working and can be up to 7m. in width, being circular, elliptical or rectangular in section. If lined, the construction can be timber, brick, masonry, concrete or steel. Drifts are normally of a rectangular or semi-elliptical section and of similar construction but are horizontal or inclined. Unprotected drifts giving access to underground workings have been known to collapse at the entrance. Even when a wall or plug has been put in place to act as a seal, collapse behind the seal is not uncommon where the cover is small, but they remain a lesser risk than shafts. Vertical shafts are insidious if hidden, especially as pits, before shafts became large diameter, had multiple entrances for ventilation or to separate the movement of coal, men and materials. In many cases conditions are worsened by previous partial attempts at filling or closure when, in some instances, timber or iron staging inserted at first seam level as a base for fill has corroded, rotted or failed, leading to loss of the fill and resulting in an open void, often with severe collapse of the surrounding ground. A general recommendation is that a safe zone around a shaft should extend to twice the distance determined by the safe angle of repose of the superficial deposits from the cap location at rockhead. As with acid drainage, changes in groundwater conditions can be the trigger for subsequent events, but increased surface loading or vibration can also be factors.

Alternative methods of sealing shafts and drifts have been developed which are considered later in conjunction with policy and risk evaluation. The justification for a varied approach is readily apparent from consideration of the numbers involved which have been estimated in excess of 100,000 (Holt, 1988).

4.2.5 Shallow Workings

The final consideration in the assessment of the effects of coalmining is that resulting from shallow workings, where the cover thickness and strength is insufficient to prevent damage at ground level caused by the collapse of the underground void. These situations are usually found in unconsolidated surface deposits and are a function of the width/height of workings combined with the nature of the overlying strata. Various different mechanisms have been suggested to explain the nature of the collapses which occur (Hassall and Bate, undated). Retreat working, where pillars are "robbed" as the area is abandoned, resulted in an increase of the roof span and a reduction in the cross-sectional area of the pillar available to withstand the loading. Increased stress in the pillars could then lead to a punching failure into the floor or roof, which particularly in the case of the floor could be caused by the ingress of water and a softening of the supporting strata, taking many years to happen. More dramatic failure occurs where the pillar crushes under load and collapse is sudden. In some situations crown holes reach the surface when the overlying thick surface deposits run into a void and movement only ceases through bulking of the material filling the available space. Although usually limited to 3-5 times the height of the seam, examples of holes reaching the surface at 10 times the seam thickness have been known. It has been suggested that a competent bed of at least 1.75 x seam thickness, above the seam, will prevent migration but these general guidance figures must always be treated with caution in view of the particular circumstances at each site (Healy and Head, 1984). Treatment in urban or development areas can be expensive, involving elaborate methods. Reclamation of shallow coal seams at Consett Ironworks for example included a pea-gravel grout curtain inserted at 1.5m centres to contain lateral flow, followed by 15:1 mixture of PFA/Cement grout injected at 3m centres (Smith and Thomas 1988).

4.2.6 Longwall Deep Mining

Surface effects from longwall deep mining are entirely different, being accurately predictable through accumulated empirical evidence, and subject to compensation which puts their consideration outside the scope of derelict land.

5.0 DURHAM IRON ORES

5.1 Ore Types

There are two main categories of iron ore found in County Durham. The formation of the Coal Measures in the Carboniferous era, as previously described, had associated with it a widespread development of sedimentary ironstones which can in turn be sub-divided into claystone ironstones and blackband ironstones. In contrast the ores in the west of the county are generally hydrothermal replacements of the Lower Carboniferous sedimentary strata, particularly limestone, related to fissure veins.

5.2 Sedimentary Ores

5.2.1 Claystone Ironstones.

The general definition of ironstones is those sedimentary rocks having more than 15% by weight of iron. It is thought that the source of the iron was primarily continental weathering, with the alternative theory of contemporaneous volcanicity being now largely discounted apart from some specific deposits. The process of transporting the iron to the sea is not fully understood but colloidal suspension, bound in with organic matter, is one method. The iron can also be transported by absorption onto organic matter or together with clay, as either part of the structure or as an oxide on the surface (Tucker, 1981). The presence of organic matter results in bacterial action producing reducing conditions normally just below the sediment water interface, causing the formation of different iron ores, depending on the prevailing conditions. Zones of ore formation therefore vary depending on factors such as the sedimentation rate, the nature and content of organic material, the composition of the inorganic sediment, the hydrological regime and the nature of the overlying water. If sulphate levels are high, as in marine conditions, then pyrite is formed, but siderite will be formed from non-marine organic mudrocks. The Durham coalfield contains little in the way of marine bands, that is to say strata laid down under deep saline water, and the iron reduction here occurred in fresh water conditions. Repeated variations in relative sea level and deltaic infill of lakes led to non-marine successions and the formation of ironstones in the sedimentary environments. Since the sediments were isolated from sources of sulphate in sea water, reduction, or oxygen removal, in this way was inhibited and the process would be methanogenic, resulting in the formation of siderite ($FeCO_3$) rather than pyrite (FeS_2) within the pore spaces of the unconsolidated sediments. The ores have a significant calcium and manganese content but little remaining organic matter. Claystone ironstones are therefore in principle a result of localised iron enrichment due to redistribution of iron in the sediments (Young, 1993). The ores occur within discrete horizons and can amalgamate to form sheets which in County Durham reach about 0.4m in thickness and in places can be over 100sq.km. in extent. In some situations the ore forms into nodules often concentrated at specific horizons rather than continuous bands. The workable iron ores in County Durham were limited to the Consett area and some way east and were extracted in conjunction with coal. The main seam was some two metres in thickness but divided into six or seven bands of approximately 30cm. with a second band of 15cm. thickness some eight metres lower.

5.2.2 Blackband ironstones.

These ores are again sideritic ironstones but defined as those with greater than 10% organic content and which lie directly over coal seams, being associated with submergence. The dominance of siderite over pyrite again confirms freshwater conditions rather than marine and the ores are generally overlain by laminated mudstone. The ironstones are derived from diagenesis of bog iron ore which occurs as discrete pods or lenses of ferruginous concretions within peat deposits. An alternative scenario has been postulated of direct precipitation of siderite from tropical swamp waters, caused by microbial organic degradation. These ores were in either event formed from iron rich waters as distinct from the claystone ironstones which were formed by redistribution and concentration within sedimentary deposits which were not significantly iron rich (Young, 1993). No specific mention is made in any records however of Blackband ironstones being found in County Durham.

5.3 Vein mineralisation

Whilst a fuller explanation of the ore bodies in respect of lead and associated minerals is necessary, and is covered later in Chapter 9, a brief description of the mineralisation process is required to explain the distribution of iron ore in relation to other ore bodies. The Alston Block referred to in the Coal Measures formation was also fundamental to the development of the North Pennine orefield. The unexposed Caledonian granite acted as a positive feature during the deposition of the Carboniferous strata due to the buoyancy of its low density core. A relatively thin cover of Lower Carboniferous rocks was formed which, in the succeeding period of folding, with some faulting and thrusting, produced a gently domed structure. The strain associated with this deformation caused dilation of NNW, ENE and EW/ESE trending fractures during the late Carboniferous/early Permian period. Although the precise mechanism is unclear it is thought that mineralisation took place during the Permian period, with the mineral fluid sources originating in the southern North Sea basin and the Carboniferous basins fringing the Alston Block and the Askrigg Block to the south (Ixer and Vaughan, 1993). The workable deposits occur mainly in the limestones and are of replacement origin related to fissures, most frequently in locations where main veins are crossed by a series of WNW trending subsidiaries known as "quarter point" veins. Where the width of the ore-body exceeds its height the deposits are called "flats" and in these cases the vein walls have been subject to metasomatic replacement resulting in workable ores often extending over 30 metres (100 feet) from the vein and in some cases to 300 metres (1000 feet) (Dunham, 1941). Distinct mineral zones occur in concentric form associated with the cupola tops, centred on the Alston Block intrusion, with the iron ores generally limited to a middle zone and further constrained by the Burtreeford Disturbance (Fig.5.1). This major faulted monocline separates some mineral deposit areas with sphalerite, a zinc ore, present to the West and siderite to the East. The siderite above the water table oxidises to the more productive ore of limonite and further oxidation can create hematite, a rich non-phosphoric ore, although this is rare in this area and more commonly related to the Cumberland ores (Ixer and Vaughan, 1993). Economic deposits in the main production area of Weardale were found in association with the dominant EW trending veins namely the Red Vein, the Slitt Vein and its continuation, Sedling Longsike (Dunham, 1990). More recent workings were related to the less prominent but still generally EW veins of Swinhope and Westerhope. This created a relatively simple pattern of workings where the major veins crossed the outcrop of the Great Limestone which was the main replacement host rock associated with iron ore. Although mainly worked with lead there were instances of individual ironstone mines, particularly in the Upper Limestone of Rookhope felltop where they constituted the widest replacement ore bodies in the North Pennines (Dunham, 1941). Secondary formations of limonite were usually larger in extent than those of the primary siderite, suggesting some secondary encroachment occurred (Dunham, 1941).

Teesdale was less important with the deposits being both more scattered than in Weardale and less productive. Once again the best locations lay along an EW vein, as at Flushiemere (Fig.5.1), which appears to be an extension of the

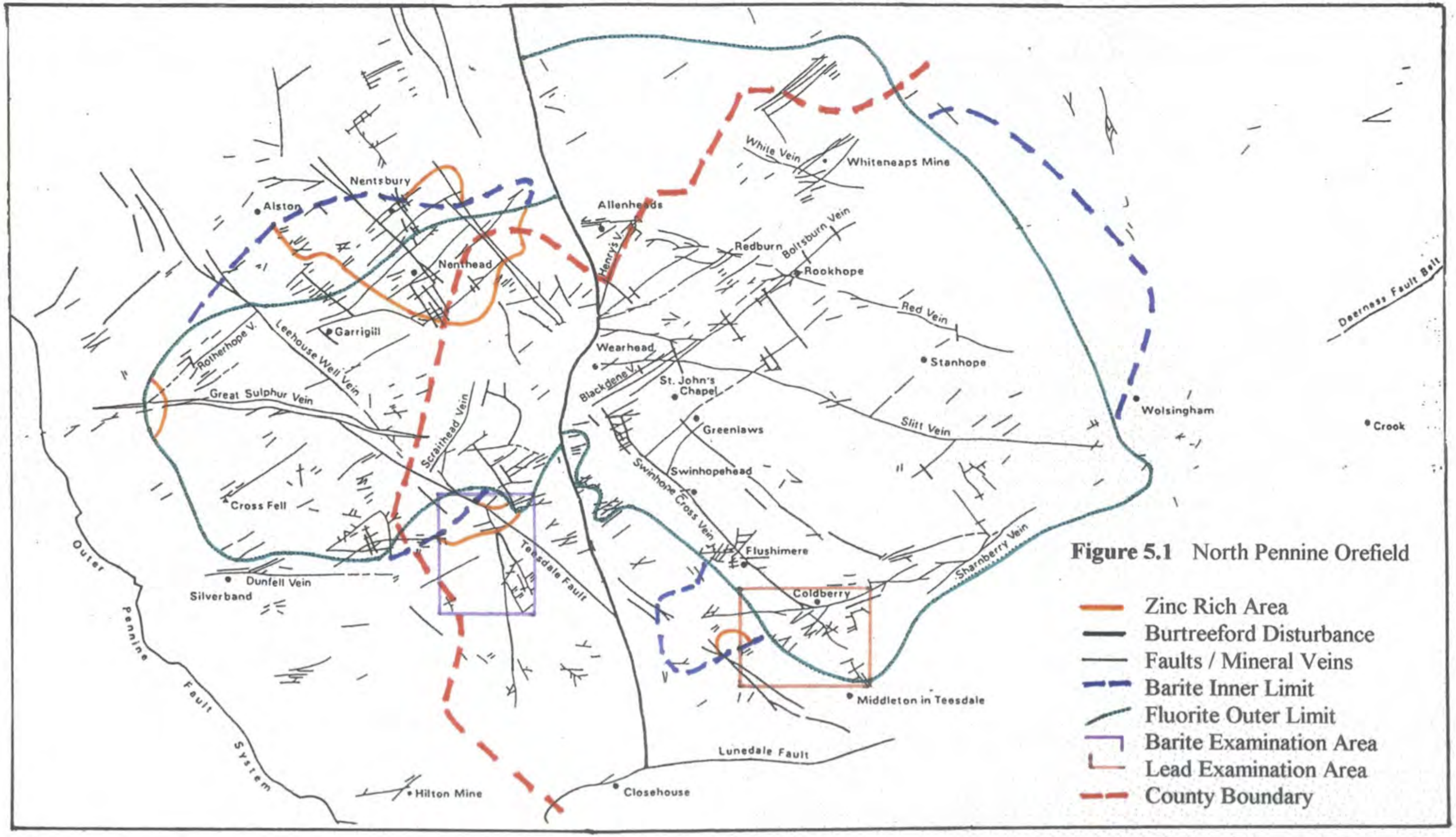


Figure 5.1 North Pennine Orefield

Swinhope vein in Weardale, and at Langdon Head which could be related to the Greenlaws vein system at Carricks, one of the main production centres in Weardale (Dunham, 1941).

6.0 IRONSTONE MINING

6.1 Claystone Ironstones

These ironstones in County Durham occurred primarily in the vicinity of Consett (Fig.2.3) and almost without exception were worked in conjunction with coal. Although an outcrop is recorded near the parish church, 32 metres from the Consett Pit, the main production was from combined working of coal and ironstone at the Berry Edge Pits. At No.1 and No.3 ore was worked with the Harvey seam, and at No.4 the Tenband was recovered at a depth of 11 metres and the No.1 Ironstone at 20 metres (County Durham Books). References have been made to deposits at Waldridge Fell and Iveston (Fig.2.3) where the ore was also won in conjunction with coal. In all three areas therefore the impact of iron ore working can be said to have been minimal over and above that caused by the dominant extractive industry of coal mining.

6.2 Vein mineralisation iron ore

6.2.1 Wear Valley

The Wear Valley deposits extended over an area some 17 km. East - West and 10km. North - South, containing 31 mines or groups with many related subsidiary excavations, levels or shafts giving some 50 working locations (Dunham, 1990). The major deposits, as earlier described, occurred in association with the main EW trending veins and generally within the Great Limestone where they were worked most easily at the outcrop (Fig.6.1). It should be expected, in conformity with the general zones of mineralisation, that ore would not be found to the west of the Burtreeford Disturbance, and only one mine is recorded, which was unproductive.

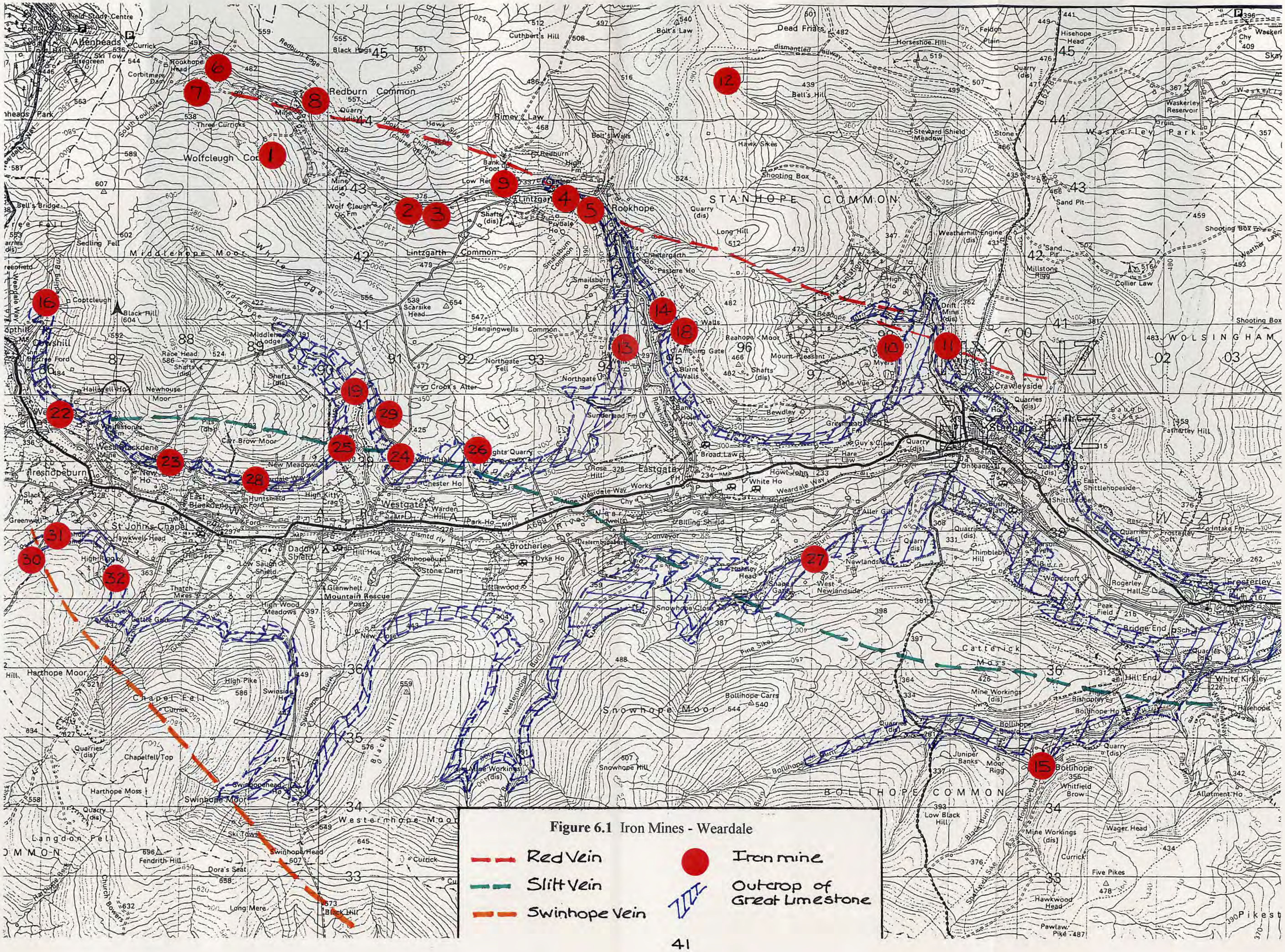


Figure 6.1 Iron Mines - Weardale

6.2.2 Teesdale

Teesdale deposits were less extensive, covering an area some 10km. square with a more fragmented distribution and a less clearly defined association of production with the large EW trending veins. There were seven mines or groups of mines involving 19 working locations (Fig.6.2). Again only one mine is recorded west of Burtreeford, with low iron and a high silica content (Dunham, 1990).

6.3 Mines

6.3.1 Weardale

Detailed examination of the mine groups in Weardale for this Study shows that 11 are related to the Red Vein running between Crawleyside and Allenheads, and eight to the Slitt Vein which can be traced from Frosterley to Wearhead (Fig.5.1). The recently worked Carricks complex contains one main group of mines and one subsidiary which are situated on the Swinhope vein, and in addition there are 10 mines which are quite remote from any of the main veins. Hardly any of this remote group have any evidence of appreciable tonnages being won, with most merely recording "evidence of workings" or "some ore obtained". Only four levels or adits have been identified and there are five opencast or outcrop sites plus one site where no details are given. In only two cases were shafts sunk primarily for iron extraction and it is consistent with patterns elsewhere that these were in the closest proximity to the Red Vein. At Hollywell, a notable exception, iron was worked with lead in an apparently large deposit. By contrast, the group of mines strung along the Red Vein were in general highly productive and of the 11 mine groups only two have not been extensively worked. A level on the Scarsike Vein, which significantly does not finally connect to the Red Vein, proved to contain not much ore and in early times the Mill Level

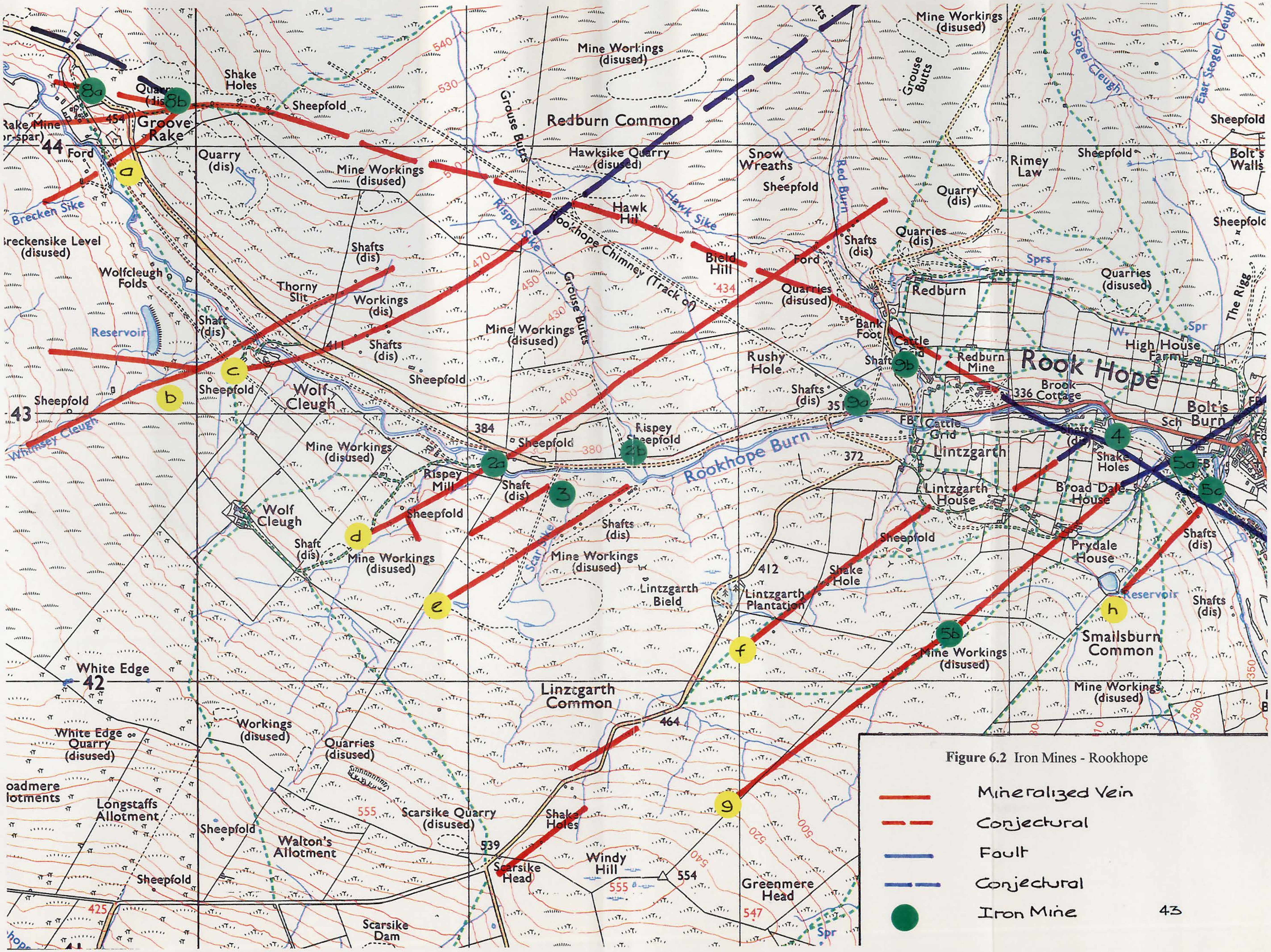


Figure 6.2 Iron Mines - Rookhope

was unsuccessful in what was described as a barren stretch between the Rispey oreshoots. Records in all other cases describe tonnages as substantial or extensive and in one case the mine is said to be the main resource of the area. Even though no records of production are available, the extent of the opencast workings show nevertheless that appreciable quantities were involved. In the majority of cases, the mines were situated on the outcrop of the Great Limestone (Fig.6.1), as the replacement ores occurred most extensively in this strata. The exception to this rule is at Rookehopehead where a complex of mines is found to relate to the Fell Limestone, although the richest mine, at Rispey, worked the Great Limestone at depth.

6.3.2 Teesdale

In respect of the Teesdale deposits, it is well chronicled that the earliest workings were in this area with records of over 2000 tonnes being extracted in the late 19th. century (Beadle, 1980). It is also well documented that the Teesdale mines were not as productive as those in Weardale and only Dirt Pot at Ettersgill, responsible for early production, is credited with a good output. Other trials have been described at Bowlees and Skears Quarry but these were generally unproductive (Beadle, 1980). As with Weardale the more productive areas were believed to a large extent to be related to the major EW trending veins. Beadle (1980) claims the replacement took place where cross-veins meet the major disturbances of the Teesdale Fault and also the Burtreeford Disturbance which tends NS. To some degree the ore deposits are also influenced by the crossing of the Manor Gill and Cleveland Dykes at the Teesdale Fault. In this light the pattern of occurrence was found to be similar to Weardale with only the Flushiemere Vein appearing to be productive and this seems to be an extension of the Swinhope feature in Weardale. Of the remaining mines or groups, two were remote and generally unproductive or too uneconomic to work. The remaining four, although in close proximity to the Burtreeford Disturbance and the Teesdale Vein, have no real evidence of serious production beyond the 2000 tonnes at Ettersgill and the original workings at Orepit Holes which appear to have had a smelting facility adjacent.

6.4 Methods of working

The method of ore working also merits consideration. Records refer to five different systems, opencast, adit/level, shaft, outcrop or not detailed (Appendix 5). The latter two can be effectively ignored as they suggest probably ancient workings, and are probably of limited extent. In addition, several mines or groups are known to have been related to earlier lead extraction and any subsequent dereliction cannot be said to be as a direct result of iron ore extraction, other than in respect of the waste materials deposited or the leachate quality. When examined through this screening process, it can be seen that only a limited number of locations are likely to be of potential concern when looking at dereliction and its possible effects (Table 6.1).

Mine Group	Opencast	Deep (Shaft)	Level/Adit	Outcrop	Limited
Red Vein	4	2	8	-	1
Remote	4	2	4	1	1
Slitt Vein	7	-	6	-	3
Swinhope	1	6	1	-	-
Teesdale	2	1	13	1	2

Table 6.1 Iron Mines - Veins

The four opencast sites related to the Red Vein are extensive as was extraction from the two shafts and two of the levels. By contrast only one of the opencast sites in the remote group appears to have been productive, and neither the levels nor the shafts give any indication of large scale economic extraction. The Slitt Vein was generally worked successfully by opencasting and only one of the six levels is mentioned in records as a trial where the ore values proved too low for economic recovery. The Swinhope group at Carricks was first worked from surface hushes and shallow shafts, with lead as the primary product and iron secondary. Although they became important during the second world war, the impact on potential dereliction from that period is limited as access, which is now blocked, was obtained primarily from a single drift known as Craigs Level. The older Rowantree Level to the east worked separately a group of flats which was inaccessible from the main area. The Teesdale workings were generally small in scale and fragmented and although many preliminary levels were tried they proved unproductive. In terms of the broad pattern of development which may have influenced the incidence of derelict land, the opencast method at both Red Vein and Slitt, and to a lesser extent at the other groups, has produced a substantial impact although this is however limited to their surface effects which are similar in many respects to those resulting from quarrying operations. Of more concern perhaps are the shafts and levels. Eleven shafts have been identified from this desk screening process, relating primarily to iron ore extraction, and thirty two levels or adits (Dunham, 1990). Shafts and levels have different characteristics and potential dangers which are discussed later and these have to be considered in relation to land use and access to the location in question.

6.5 Reclamation records

Investigation of derelict land records shows that reclamation is shown to have been carried out, at only one site, Sunnyside Opencast Workings, although this is incorrectly described on the reference plan as Sunnybrow Colliery. Only six additional reclamation sites are in the relevant area of Weardale of which three are former railway stations, one a quarry, one a former sewage works and one which, although plotted at Cowshill, was wrongly identified as Beamish Mary Colliery. In Teesdale there are only four reclamation sites in the appropriate area, of which two are abandoned quarries, one an unused railway and one a gravel pit. The schedule of derelict land compiled by the County Council includes the Middlehope Mine as justifying reclamation and the Rigg Mine as derelict but not justifying treatment. It appears therefore that no systematic attempt has been made to treat any of the former iron ore extraction sites on the basis of safety. There may be a substantial number of old shafts and levels and, of lesser concern, opencast workings which should be examined further to see if potential problems exist.

6.6 General Review

When the actual locations and nature of the extraction points are examined more closely in respect of their proximity to sensitive land use or likelihood of public access there is an appreciable reduction in the number of sites which may be at risk (Appendix 5, Fig.6.1). There are 16 mine workings, opencast sites, shafts and levels related to the Red Vein not all of which appear to warrant further examination. Excluded from the number are opencast sites which can generally be assumed after the lengthy passage of time since the extraction was carried out to have little residual risk of settlement or slippage and are in any event, clearly visible. Some are close to footpaths or roads but others are in the proximity of hill paths, which are probably little used, and more again are close to roads. In the case of the latter any inherent problems will probably have been assessed as part of ongoing road maintenance. Of the remainder, one was originally a lead mine prior to being worked for iron and any problems are not therefore directly attributable to the winning of iron. The extent of the potential problem related to former iron workings in the vicinity of the Red Vein is examined later in more detail. Of the 14 sites considered Remote from the main veins, and again ignoring the opencast works, only four are adjacent to footpaths and one, described as an outcrop has probably been incorporated into a road. Three of the former sites relate to small country paths and do not appear to justify assessment or treatment. Only one level, in Frosterley, requires serious consideration. There are again 14 sites associated with the Slitt Vein of which three appear at first sight to warrant further examination. One is in fairly close proximity to housing and the other two are reasonably close to an apparently well used track. The remaining eleven cases were either opencast sites or in remote locations and unlikely to be of concern. The mines on the Swinhope Vein have a recorded extent of some 2 square kilometres extending across O.S. grid blocks NY 86-87 East and NY 36-38 North with a description as an area of hushes and shallow shafts (Fig.5.1). In view of the remoteness of the site and the absence of any public rights of way this general area does not cause any concern. The main entrance to the series of drifts, known as Craigs's Level, should however be checked in view of its location which appears to be on a bridleway. An earlier opencast site nearby is within 100 metres of the track but can easily be checked visually. To the east of the Carricks Mine the Rowantree Level was driven but this is marked at the dead end of a track which has no public right of way and is probably a low risk.

In Teesdale, 20 sites are scheduled of which the only ones requiring further consideration seem to be a set of six drifts, lying close to the well-used long distance footpath, the Pennine Way (Appendix 5).

In total therefore, of the 73 mines examined, some 23 appear at first to merit more investigation but closer inspection reduces the need to perhaps 16. A group of mines associated with the Red Vein will be looked at more thoroughly to evaluate the inherent risk and test the acceptability of the initial assumptions made.

6.7 Screening of works locations against reclamation

6.7.1 Red Vein, Rookhope

What appears to be a simple structure in respect of iron workings related to the Red Vein is compounded by the presence of generally NE-SW trending veins which were previously worked for lead. It is known that the productive areas of ironstone flats were usually at the ends of ore shoots or the divergence of veins (Dunham, 1990) and this is confirmed here at the Red Vein by the location of the mines where the main vein intersects the cross veins, as at Groverake and Boltsburn. Exploration of the Red Vein from the Mill Level and the two Rispeysike Levels proved it to be barren in this area but a variation to the concentration on the Red vein occurs at the Rispey shaft, which proved to be the main source in the area for many years, working the adjacent Rispey vein in the Great Limestone at depth. Similarly at West Groverake the ironstone was found in the Burtree Pasture vein shortly before its junction with the Red vein. In all 18 features are present of which five were opencast, leaving 13 mines consisting of nine levels, two shafts, a former lead shaft which had been re-opened and one undefined. Of these, 11 are situated in a concentrated area between Groverake and Rookhope (Fig.6.2).

Rispey	NY9109-4280 - Shaft (2a) - Footpath 40 metres.
	NY9163-4285 - Level (2b) - Road 40 metres
	NY9164-4286 - Level (2b) - Road 50 metres
Scarsike	NY9131-4270 - Level (3) - Road 90 metres
Low Fulwood	NY340-4292 - Former lead (4) - Footpath 50 metres
Boltsburn West	NY365-4283 - Level (5a) - Footpath 10 metres
	NY9275-4217 - Shaft (5b) - Footpath 40 metres

	NY9376-4272 - Level (5c) - On footpath
Groverake	NY989-4416 - Level (8b) - Footpath 30 metres
Mill Level	NY9242-4302 - Level (9a) - Road 30 metres
	NY9258-4323 - Drift (9b) - Road 10 metres

No reclamation is recorded in the area but it can be seen that only a limited number of potential problems remain which are clearly related to the main vein system, giving a relatively easy analysis for such a productive ironstone area.

6.7.2 Cross Veins

It is when one looks at the adjacent cross veins and their lead deposits that the picture appears to become rather more complicated with a number of additional features visible on the O.S. sheets. The extent and nature of workings vary from vein to vein as set out below.

(a) The Burtree Pasture Vein cuts the Red vein at Groverake (NY9002 - 4445) but was not productive approaching this junction at its east end and lead stopes are quoted as being worked out one mile to the south west of the Rookhope Burn.

(b) At the Wolfcleugh Old Vein mainly ancient workings are referred to, together with the disused Wolfcleugh Mine, which is visible on O.S. sheets, and a pumping shaft which could be a misplot (NY9019-4324) of a disused shaft shown to the north west. The workings drained to a level connected to the Scarsike vein described below. A slit and workings with shafts are shown on a conjectural projection of the vein to the north east of the road.

(c) The Wolfcleugh New Vein diverges from the Old and is demonstrated by superficial workings to the north east beyond the road. A level mentioned at NY9069-4304 is not plotted and failed to reach the Red vein.

(d) The Rispey Vein is described as having a line of shafts to the north east of the road but nothing is shown and the heaps contained only a little fluorite. The Mill Level proved the junction of the Red and Rispey veins to be unproductive and the shafts in the vicinity of the Red Burn to the north appear to be further prospecting on a conjectural line. A shaft and disused workings to the south west of the main shaft are well beyond the recorded production area for iron. The level draining Wolfcleugh Old Vein can be traced by a line of old shafts running south west before it turns north westwards via Wolfcleugh pumping station and Rispey engine shaft to Groverake. A level at NY9206-4288 is not shown but further shafts to the north east could indicate attempts to locate the (e) Scarsike Vein extending to the Red vein.

(f) The Fulwood Vein is said to have been worked extensively at NY923-424 but nothing is evident other than shake holes. Further shafts in the vicinity of Low Fulwood mine may be related to recorded unsuccessful attempts to trace the vein north of the Red vein.

(g) Shafts on the line of Patersons Vein are presumably related to attempts at better development of this vein and of the (h) Boltsburn Vein which is described as poor in this area.

Disused mineworkings on the Red vein and to the north on Redburn Common are unexplained but possibly indicate exploration, as at

Hawksike Quarry, lying as they do on projections of Wolfcleugh and Rispey veins beyond the main vein which proved barren in this area.

Examination of the cross veins therefore demonstrates little relationship to the ironstone workings of the Red vein which can be assessed independently in accordance with the general principles dictating the distribution of this ore. The mining of the cross veins, principally for lead, can be seen as a more simple version of the case studied in depth at the Coldberry area as the prime example of this mineral.

7.0 IRON AND STEEL PRODUCTION

7.1 History

Iron has been mined in Great Britain from very early times and Iron - age tribes were recorded by the Romans as using iron currency bars which would have been formed from easily accessible non-sedimentary ores or possibly ironstones. At this time reduction of the primarily hematite ore was carried out, using a blast of air, in small bloomeries which were simple to construct and could be built adjacent to the ore deposits. This was an important consideration when transport was difficult and slow. Reference to this process was made locally when one of the Bishop of Durham's foresters leased land for a bloomery in 1386 near Evenwood (Whellan, 1894). Prior to the development in the late 17th.century of better methods, small quantities of so-called "natural" steel were manufactured using one of two continental methods both of which depended on ores referred to as "Swedish type" which had a high iron content but were non-phosphoric. There was also a significant manganese content which had an important function in keeping the slag fluid and thus capable of being re-worked to reduce the carbon content. The first records of this process in the North East of England concern the establishment at Shotley Bridge in 1686 of a community of German immigrants who set up the "Hollow Sword-Blade Company". The Weardale ores were found to be similar in character to the Carinthian or Styrian ores of central Europe and were capable of being refined to produce either a carbon free wrought iron or a simple steel (Barraclough, 1976).

7.2 Processes

The development which led to the demise of "natural steel" began in central Europe, was first recorded in Prague in 1574, and was documented with practical accounts in Nuremberg in 1601. This cementation process producing so called "blister steel" was patented in England in 1614 and was the method which eventually superseded the "natural steel" supplies in the Derwent Valley on the edge of County Durham in the early 18th. century, although both processes continued in parallel for some time. It had been realised that bars of wrought iron could be carburised and converted to steel by heating them slowly when packed in charcoal and this led to the development of a number of furnaces in the Tyne and Derwent Valleys which by the mid 18th. century were thought to produce about 800 tons per year, or more than two thirds of the total English production. This larger scale of production appeared not to extend into the present County Durham as furnaces at Allensford Mill and north of Consett were the south westerly limit of the steelmaking area (Barraclough, 1976). Iron making consists essentially of the process of melting the ore in a furnace and, by use of a flux, the separation of the impurities. Production from the middle ages had depended on charcoal as the heat source but, as timber shortages developed, the small scale attempts to smelt iron using coal, which were made in the first half of the 17th century, were repeated. Success was achieved by Abraham Darby at Coalbrookedale, sometime after 1730, and the first coke fired furnace in County Durham was recorded at Whitehill, near Chester-le-Street in 1751. The co-occurrence of coal and iron in the Carboniferous Coal Measures was therefore ideal and the Consett Iron Company, established in 1840 as the Derwent Iron Company, built blast furnaces to utilise locally mined claystone ironstone and limestone, to be used as flux, brought from quarries in Weardale. The local ores extracted at Consett, Iveston and Waldridge Fell were recorded as being 2m. thick with an iron content of 26% (Wilson, 1973). Interest also began in the iron carbonate or spathic ores in Weardale and in 1846 the Weardale Iron Company, later to become the Weardale Iron, Steel and Coal Company, was founded to utilise large tracts of ironstone which were leased in the Wolsingham and Stanhope areas. The spathic ores initially fed a single furnace at Stanhope which operated as a reverse of the Consett operation by relying on coke carried from the coalfield to the ore and limestone production centre. It was stated however to be only in blast for part of the year and was probably not long lived.

At about the same time, the Middlesbrough ironmasters, Bolckow and Vaughan, developed four furnaces at Witton Park, later increased to six, to make use of the Durham ores (Anon, 1992). About a hundred puddling furnaces were also in use for refining the iron. The Consett ores were, however, almost exhausted within a decade and supplies had to be eked out by mixing with Weardale ores which resulted in only a mixed quality product. Attempts were even made as early as 1849 to procure Jurassic alternatives from the coast at Whitby and the Esk Valley, which supplies were also fed to Witton Park.

The Weardale Iron Company then built six furnaces at Tow Law and a description given at the time these works were being developed, and reproduced in 1894, provides not only an interesting insight into the reasoning behind the establishment of the ironworks but also a clear impression of the location and quality of the ores involved (Whellan, 1894).

> *"In the following year six others were erected in a more suitable situation at Tow Law, where the Durham coalfield terminates, and in contact with the mountain limestone formation, in which are contained the deposits of iron ore required for their supply. The ore is conveyed to the ironworks partly by the public line of railway connecting Tow Law with Stanhope, near which last-mentioned place the mining field begins; and partly by a private branch from that railway, constructed by the iron company, and extending into Rookhope, which latter is at present being further prolonged into Middlehope. The mines of ironstone become, about this latter place, much more numerous, larger, and of richer quality than in the immediate neighbourhood of Stanhope, and this superiority continues throughout nearly the whole length of Weardale westward, or for a further distance of about fifteen miles The ore which these mines afford is found in the same veins as those out of which the lead ore of the district is wrought, although it is found, for the most part, that where the lead becomes the most abundant, the quantity of iron ore diminishes, whilst where the iron is more plentiful, the lead ore as frequently becomes more sparingly diffused. The ore is met with not only in the veins themselves, but extends on one or both sides of them, by an expansion which is locally described as flatting out, or into flats - that is to say, into horizontal beds, for very variable distances from the cheeks, or sides of the true vein,*

sometimes, indeed, to the width of several hundred yards, and of a depth or thickness of from 15 to nearly 70 feet. These are, in some places, so near the day as to admit of being wrought by open work, or in the manner of quarries, whilst in other cases they have to be followed and wrought underground, in the same manner as is most usually done with common lead mines. The quality of the iron afforded by these ores is of the very strongest and best description, especially that made from the sparry carbonate, which partakes largely of the toughness of the Russian and the stiffness or body of the Swedish iron. In fact, if smelted with charcoal, it would be fully equal or superior to the best of these; and even if smelted with the coke of the county of Durham, and subsequently worked up with charcoal, it is very little inferior to them for any use either in iron or steel. Indeed there are extant old documents which show that, about two centuries ago, the iron ores of the Bishop of Durham's manor and mines in Weardale were worked for the purposes of making steel as well as iron. The manor is of great extent, reaching from near Witton-le-Wear to Alston Moor, at which latter place a portion of these ores, although much less abundantly is also found, and the whole manor of Weardale as to its iron is held by the Weardale Iron Company."

7.3 Developments

By 1836 however large reserves of iron ore had been discovered in Cleveland, followed by those on Humberside and in Northamptonshire and this began to distort the prevailing economic markets. Commercial viability of iron ores was generally limited to iron contents above 28% and even this can be considered low in relation to, for example, Australian ore at 60%. The Cleveland ores, although not much above the limit of viability, benefitted from being more massive deposits and were more economically extractable (Young, 1993). From 1850 these ores were fed to both Witton Park and Consett and the importance of the Jurassic ironstones increased across the country until by 1855 it was estimated that 75% of national production was from these sources with the bulk of the remainder from the Carboniferous ironstones. By 1872 Consett had ceased to use local ores although the search for the most economic supplies continued, starting in 1855 with the leasing of land at Alston Moor and Garrigill to exploit the Weardale resources but this was abandoned in 1864 when the company became the Consett Iron Company (Wilson, 1973). When the resources were exhausted it was estimated that the Alston mineralised block had produced some 1.85 million tons of iron ore.

Later, beginning in 1856 but then assisted by the construction of a more direct rail link in 1867, West Cumberland hematite ore was transported for blending with the Cleveland supplies. The puddling process in use, producing iron rails, benefitted from limited phosphorus content and when this market collapsed in 1876 due to competition from steel, attention was transferred to plate for shipping. The same principles applied however and supplies of West Cumberland ores which in 1868 had constituted 83.5% of Consett requirements, continued (Warren, 1990).

As interest in the Mesozoic ores increased more furnaces were built on the edge of the coalfield to optimise freight journeys on the new rail systems for Cleveland ore and Durham coke. These included Coxhoe in 1856 and Ferryhill in 1858. Seaham was also developed at the same time but was more dependent on imported ore and, together with Darlington, was mainly concerned with working cold metal.

7.4 Further Changes

In 1856 the Bessemer process was first announced, heralding a period of rapid change in steel technology and furthering the advance of steel for general industrial use. The first furnaces were acid, or in other words employed a silica lining, which required a low phosphorus ore. Iron ore is impure, with variable contents of phosphorus, silica, sulphur and manganese. The iron also has an affinity for oxygen which can be driven off by heating, but the other elements are more difficult to remove. The Gilchrist-Thomas process, or basic Bessemer, which was established in 1879, used an alkali lining and thus removed the need for a low phosphorus ore. In Great Britain the acid process continued to be favoured and, since the large British deposits were relatively rich in phosphorus, the imports of ore grew, continuing the move towards steel production based near deep water facilities. The last Carboniferous ores were worked in 1950 although for the three decades prior to this only blackband ironstones had been worked in conjunction with coal. This trend towards imports hastened the end of the British ironstone industry although Frodingham ores continued to be used until 1988 as an iron rich flux to the imported ore. The Cleveland ironstones, on which some Durham furnaces had depended, and which had supplied more than half the British need between 1875 and 1900, were replaced earlier in the 20th. century by the Midlands Jurassic ores.

Bulk production of steel at Tudhoe and Consett (Fig.7.1), to replace the traditional use of wrought iron, developed from 1856 and 1860 respectively and although depletion of the local ores caused progressive closure of the inland furnaces, with most developments proving to be relatively short lived, these two continued with Tudhoe still using Weardale ores until at least 1894. Consett remained dependent on non-phosphoric ores and from 1870 had begun to import Spanish hematite ores which also had the benefit of a high manganese content and were therefore ideal for the Bessemer process when the general changeover to steel occurred here in the 1880's. The only suitable alternative supplies, of Cumbrian hematite, had become uneconomic and supply through Tyne dock of the Spanish ore allowed continued production based on the substantial economic advantages of local Durham coke. Use of the East Midlands Jurassic ores was not even considered before 1914 and discarded on the grounds of the disproportionately expensive unit transport costs of these lean ores and their high phosphorus content (Wilson, 1973). In the 1930's the troubles leading to the Civil War threatened Spanish supplies and the company attempted, unsuccessfully, to invest in West Cumberland ores. Wartime restrictions led to

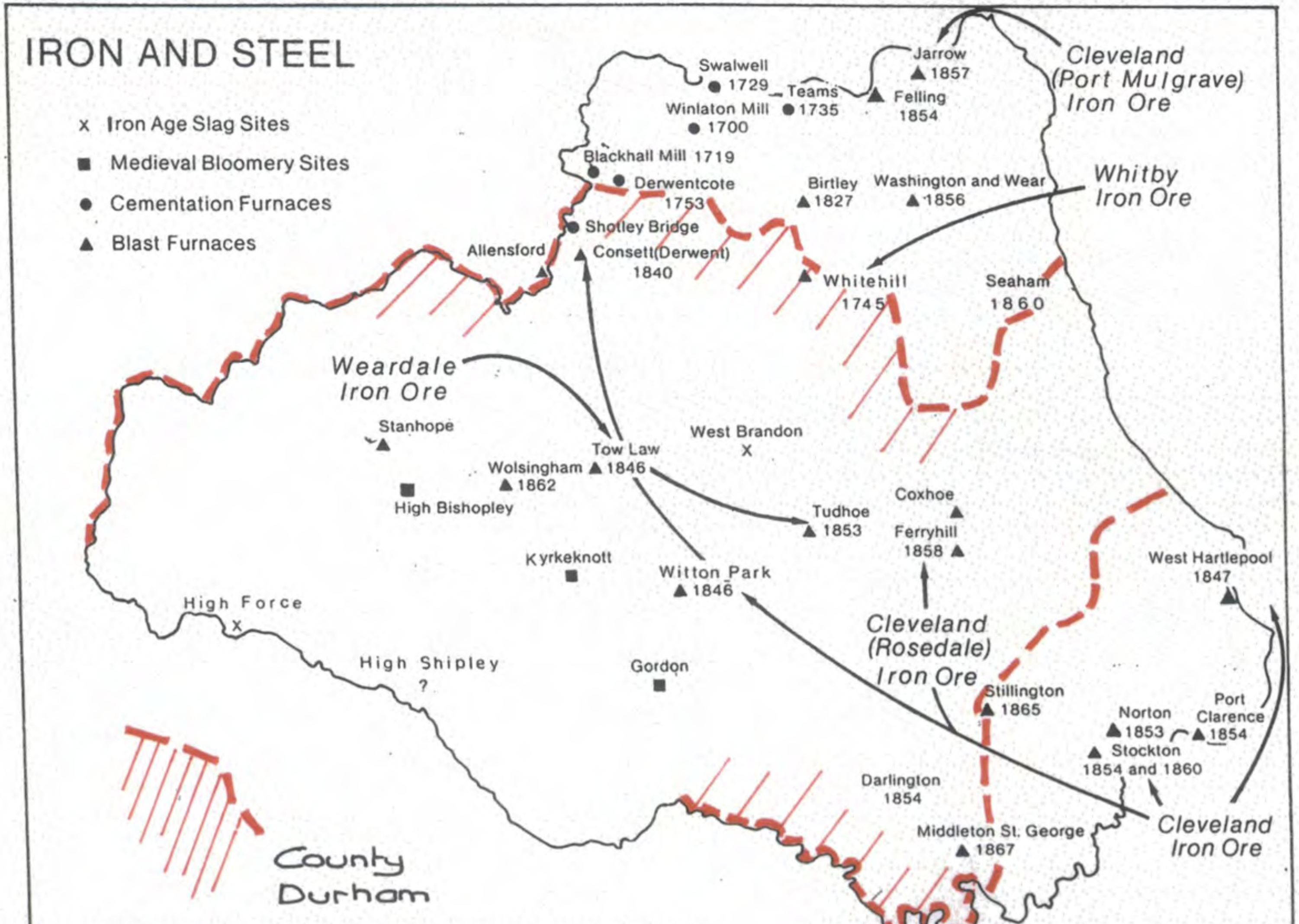


Figure 7.1 Ironworks - Historical (After Anon.1992)

less than one sixth of ore supplies being imported in 1943, with production dependent on home sources and sinter. Post war operations relied mainly on imports although in time many of the furnaces had basic linings fitted, allowing the use of phosphoric ores. There were in fact only limited numbers of ironworks locations in the county and only two survived into the present century. Witton Park, as an example, declined rapidly after 1875 with the works intermittently closed and open during 1882 and 1883, until final closure occurred in 1884. The explosion in 1880, which blew out the side of furnace No.5, was perhaps an indicator of a failing operation. It has been said, with the benefit of hindsight, that Witton Park was John Vaughan's one blunder in an otherwise successful career (Anon, 1996).

7.5 Recorded Ironworks

There have been relatively few iron and steelworks in the County, and of these, some can be discounted as low risk. Others are addressed later in this Study.

1745 - Whitehill - First coke fired blast furnace in County Durham.

1840 to 1893 - Consett - started with local ironstone and acid processes but became reliant on imports and use of the basic process became necessary. Site reclaimed.

1845 - Stanhope - Blast furnace for local ores.

1846 - Tow Law - Six blast furnaces for local ores - site reclaimed

1846 - Witton Park - Four blast furnaces to use local ores, then replaced by Cleveland imports. Roughly levelled.

1853 to 1920's - Tudhoe - Originally to work pig iron from Tow Law but operated two blast furnaces for some time. First use of Bessemer converters in the area from 1861. The operation was moved to the Tees in 1901 and the site was reclaimed for a housing development known as Bessemer Park.

1854 to 1896 - Darlington - Cold metal processing only.

1855 - Seaham - Cold metal processing only within the Dawdon Colliery complex.

1856 - Coxhoe - On plans - remnants visible on site.

1858 to 1890 - Ferryhill (West Cornforth) - To process Cleveland ore - reclaimed.

8.0 IRON MINING AND PROCESSING - PROBLEMS

8.1 Mining

The problems associated with iron ore mining are a combination of those identified with coal mining, both deep and opencast, but including the additional factor of operations which are more akin to quarrying. The winning of sedimentary ironstones was carried out in County Durham, in conjunction with coal mining and therefore had little impact on the creation of derelict land. In contrast, the deep mining of vein mineralised iron ores produced the same type of impact as that of coal mining, albeit with some distinguishing features. Volumes of ore produced were, in general, smaller than at coal mines and the waste was different in content, being associated with harder strata than the softer materials of the coal measures. Mine shaft dimensions were also smaller but in other respects the mines were similar, giving the same risks, although locations were seldom urban and iron mines far fewer in number. Ironstone opencast mining in the county was more akin to quarrying in that overburden was not excavated and then replaced after gaining access to the ore. Where "flats" were accessible close to the surface, the ore was exposed by excavation and the overburden cast aside, leaving a pit or vertical face with adjoining mounds of waste. Subsequent weathering has produced more natural looking features which do not justify large scale reclamation, although selected sites could benefit from limited works where public access is a factor.

8.2 Processing

It is in the consideration of dereliction produced by the processing of iron ores that the real differences occur. The manufacture and refining of iron and steel products has been a constant entry in the schedules of potentially contaminating processes, produced by agencies both in Great Britain and abroad, demonstrating the importance attached to the activity. Much of the concern however is related to the usual presence of a coke and bi-products works, associated with the iron or steel production, the consequences of which are discussed later. It is also frequently the case that the iron and steel works would be located at a colliery and the normal consequences of mining activity would have to be investigated and dealt with. The physical difficulties of redeveloping iron and steel making sites are related initially to the dismantling and demolition of the above ground structures, and lack of care here can lead to such operations causing more contamination than the normal process of the plant. Below ground, the extensive foundations and other structures such as cellars, pits, cables, pipelines and piles will frequently have been successively redeveloped leaving a complex of unrecorded and dangerous obstacles. Air shafts, flues and drainage systems at depths from 0.3m to 10.0m below ground level and measuring up to 2m in diameter or height have been discovered in recent reclamation schemes (Smith and Thomas, 1988). Further difficulties can be posed in the form of fused slag balls, or ladle linings known as "skulls", which can contain appreciable proportions of iron and are therefore both extremely dense and to a degree, flexible. Breaking up for removal by impact methods, blasting or cutting is as a consequence both time consuming and expensive, resulting frequently in modification of site redevelopment proposals to accommodate the presence of these almost irremovable obstacles. Although iron ores contain substances to varying degrees, such as lead, sulphur, arsenic and copper, they are not in their normal state considered to be dangerous (Barry, 1981). The production process concentrates contaminants in the wastes which consist mainly of slag, flue dust and slurries, refractory discards and waste water. By far the most important of these, quantitatively, is slag which varies in content and characteristics depending on the process from which it is derived. Slag consists of the molten silicate complex formed from the combination of earthy matter in the ore with the fluxes and fuel.

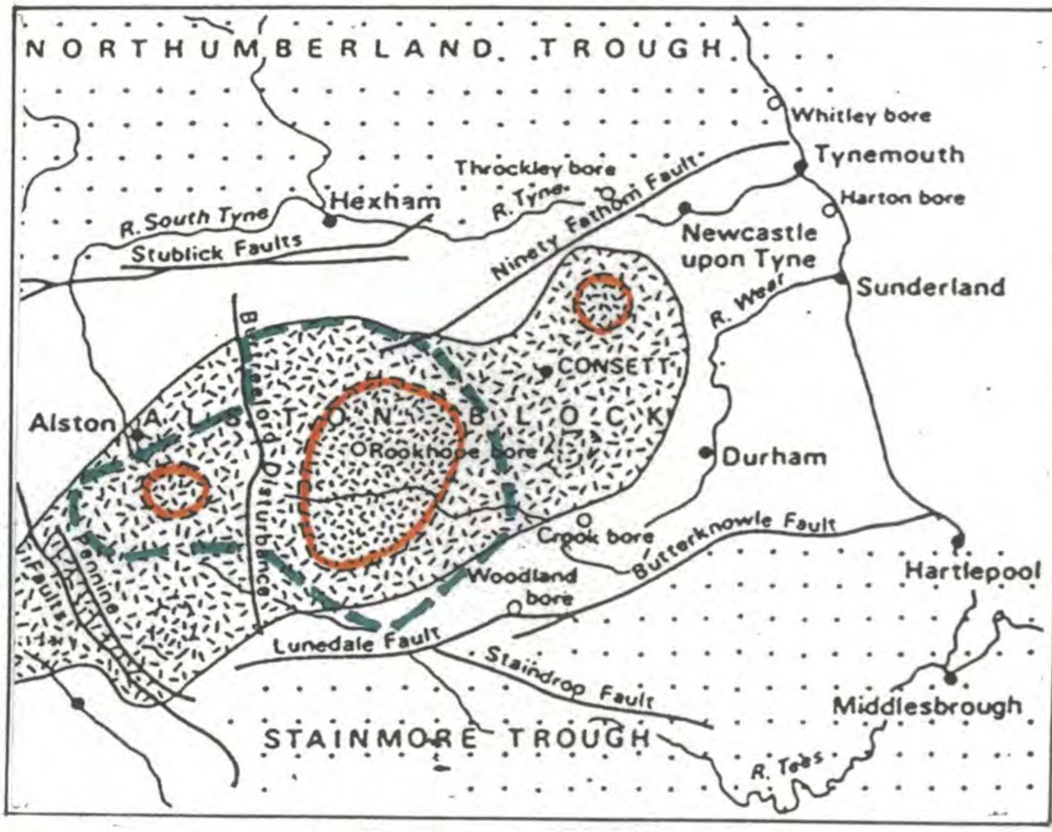
The action of mixing with other constituents during re-use combined with weathering can cause dramatic changes to occur. The most frequent trigger of this so called "instability" in blast furnace slags is the free sulphate content of the slag. The mechanism of this constituent reacting with other materials to form the compound ettringite, has been identified, and real time tests are available to prove the likelihood of the associated disruptive volumetric expansion (Smith and Thomas, 1988). The composition of steel slag, however, is fundamentally different and can vary both chemically and mineralogically, in contrast to blast furnace slags which are more consistent. Steel slags are generally low in sulphur and any tendency for expansion to occur is most often due to the presence of free lime, resulting from the addition of limestone during the process. Most modern slags are controlled and can be reused for a variety of purposes. A good example of the expansive properties of slags occurred at Hartlepool during reclamation of a disused site containing a mixture of both iron and steel slags. Considerable uplift took place in the disturbed material resulting in delays to the development of the area, whilst monitoring was carried out, until it was certain that movement had ceased. Flue dust and slurries can contain significant quantities of lead and zinc, as do refractory linings which can be produced in considerable volumes. Waste water, as with solid contaminants, is largely influenced by the output of the cokeworks from both by-products and coke quenching, but the blast furnace operation and finishing processes can both produce effluents with heavy contents of suspended solids and a range of other pollutants such as phenols, cyanides and ammonia. Before the exercise of environmental controls, only waste which could be recycled without pre-treatment would be re-used and all the above materials would normally be dumped with the slag. Leachate from the heaps could therefore interact with a range of source materials and the possibility always exists of contaminants being taken into solution or suspension. The significance of this depends partly on the prevailing pH levels as heavy metals will only become mobile in acid conditions, which can be caused by the presence of iron despite the normally alkaline nature of most heaps.

9.0 ORIGINS OF VEIN MINERALS

9.1 Mineralization

The mineralization of the North Pennine Orefield is generally thought to have occurred about 300 million years ago, in the late Carboniferous or early Permian period (Pattrick, 1993). The source was basinal brine which found in the adjacent land mass the high permeability pathways required for focussing and concentrating fluids. It has been suggested that the presence of hydrocarbons in this orefield, where they are not found in others, indicates a relationship to the Carboniferous basins rather than the post Variscan movements. One probable source was the Southern North Sea Basin which underwent considerable subsidence in the Permian period and through the Mesozoic (Pattrick, 1993). The consequent mineralization occurred in rocks from the Ordovician up to the Permian but mainly in the Dinantian and in particular in the Great Limestone of the Namurian. It is thought that the mineralization was a two stage process with the first event related to the intrusion of the Whin Sill.

As discussed earlier in respect of the iron deposits, the structure of the sub-surface Alston Block affected folding, with stretching of the Carboniferous strata due to the buoyancy and rigidity of the block beneath (Fig 9.1). This folding, with some faulting and thrusting, produced a domed structure with a major monocline, the Burtreeford Disturbance, running generally north - south, and many faults which were dilated through deformation and formed the host structure for the mineralization process. The orefield is approximately 45km. east - west and 35km. north - south and is itself bounded by major faults on all sides except the east, where it is buried below the Upper Carboniferous and Permian rocks of the Durham Coalfield and coast. The vein structure formed was complex with three main groups and many subsidiary ones. The main productive veins run ENE, with a set of cross veins angled NNW and a group

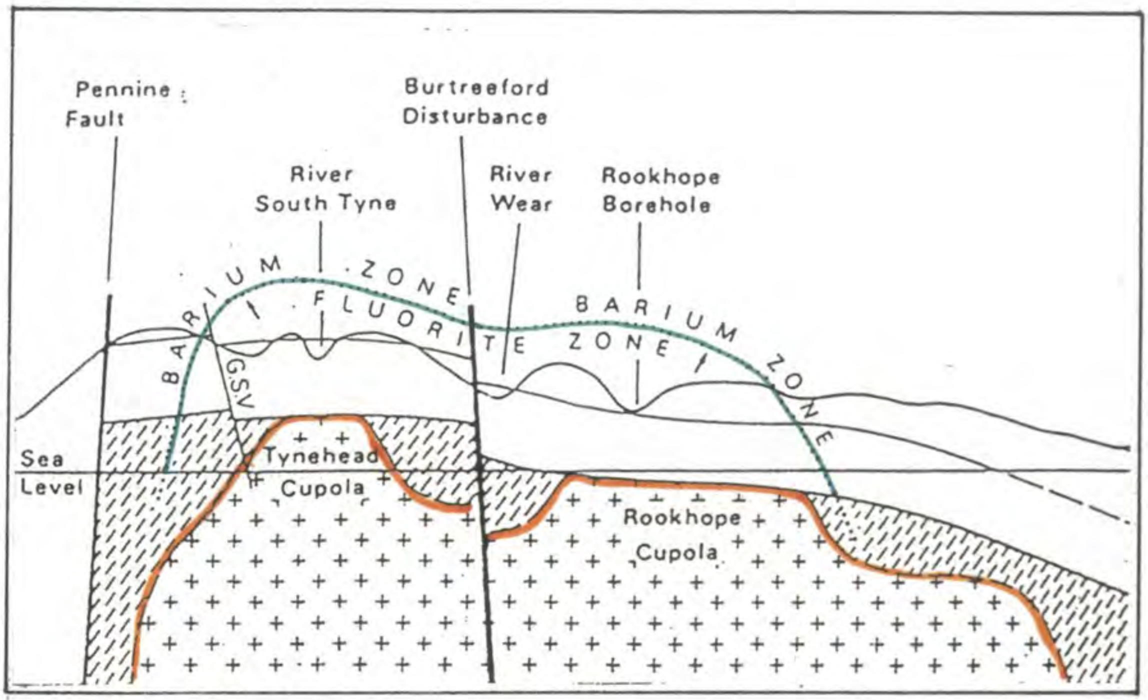


Sedimentary Basins

Granite Cupola

Fluorite Zone

Figure 9.1 Alston Block
(After Jones & McGraw,1980)



Weardale Granite
Basement Slates
Fluorite Zone

Figure 9.2 Alston Cupola
(After Smith,1980)

known as the quarter point veins generally trending WNW (Jones et al, 1980). The Burtreeford Disturbance, 30km. long and stretching from Allenheads to the Lunedale Fault, has a displacement of 150m. and divides the orefield in two with different mineral contents to the east and west of the disturbance. The spatial zoning of the orefield is well documented, with a central fluorite area of some 600sq. km., generally correlated with the sub-crop of the Weardale cupola (Fig.9.2) and thought to be due to the passage of deep chloride fluids rising through the granite. Passing through an intermediate zone, where neither is mutually exclusive, an outer zone of barytes is reached where the mineralization is believed to have been caused by the chloride fluids mixing with the shallow sulphate brines. In general the inner central core contains only fluorite with little in the way of sulphide minerals. Moving outwards lead ore, galena, starts to occur in a fluorite matrix which on the west side of the Burtreeford Disturbance has an equal proportion of sphalerite or zinc ore. On the fringes of the fluorite zone the galena continues and then diminishes as the dominant matrix becomes barytes ($BaSO_4$). This seems to have little rational relationship with the other barium ore of witherite ($BaCO_3$) which occurs elsewhere in the coalfield (Fig.5.1).

9.2 Extent of Ores

The mineralized veins are small faults with little vertical throw so that competent strata were present in both walls and the chance of the vein becoming blocked with shale was diminished. Thickening of overlying sandstone, early mineralization sealing the walls and baking of walls above and below the Whin Sill are all factors affecting productivity (Ixer, 1993). The minerals were deposited in tension cavities, sometimes enlarged by solution, and also by replacement and infilling of solution caves. These are known collectively as 'flats' and the best locations are at the intersection of other veins with quarter point veins where widths of tens of metres are known. Wrenching of up to 30 metres, which displacement opens up the veins, occurs more frequently where the direction is EW rather than WNW (Smith, 1980). In these circumstances the flats have been most commonly formed by replacement, first with the introduction of magnesium to create dolomite, then iron. Less frequent are the occasions where solution cavities have been filled by hydrothermic minerals. Of over 600 veins explored only 26 are of the latter type but these account for 15-20% of lead concentrates and 80-90% of zinc (Smith, 1980). This can be explained by the relative thickness of shale above the limestone constricting the flow and forcing fluids to migrate laterally. Flats are found at the end of ore zones, particularly in quarter point veins, where the iron which frequently occurs is probably an early phase deposition linked to the Whin Sill. In general however the WNW veins are poor and the most heavily mined are the lead and zinc bearing ENE veins especially where these are cut by the quarter point veins. Concentration of iron in the quarter point veins thus led to a simpler pattern of deposition than with other minerals. Fluorspar tends to be present at the EW extremity of the directional range in the quarter point veins rather than the WNW-ESE and only as vein deposits, not in flats. Of the recorded fluorspar production, 85% up to 1977, was from the main quarter point veins, White, Red, Sedling and Slitt (Fig.5.1), whilst only three of the ENE veins, Blackdene, Ireshopeburn and Rotherhope Fell were worked at all (Smith, 1977). A pattern of ribbon like deposits thus developed lying one above the other, generally in vertical fissures in the Great Limestone but also the White Whin, a clay carbonate rock formed at the margin of the intrusion. The extent of working is not however simply determined by the quality or quantity of the deposit. An oreshoot is defined as ore worked with profit, or with hope of profit, and can be related to the two types, either vertical veins or horizontal flats. As with other forms of mining, the actual commitment to production depends on unit extraction costs which are determined by accessibility, quality and quantity. The favoured beds were the hard rocks of limestone, dolerite and sandstone. Veins are most productive in the Great Limestone, which is 18-21m. thick (60-70ft.), whereas the remainder are less than 9m.(30ft.). Flats were found in all limestone strata but mainly in the Great Limestone which accounted for 87 out of 126 oreshoots of this type. These were associated with diverging fissures in the vicinity of intersections (Dunham, 1990). Particular circumstances can prevail as when a washout has occurred with sandstone or grit replacement and individual oreshoots can then be up to 300ft. (91m) high (Dunham, 1990). In other locations a vertical pipe from a conjectural emanative centre for the mineralizing fluids can produce similar effects and there are examples of mines developed specifically to capitalize on these circumstances. Although extraction tended to be from levels driven through outcrops at the surface in some cases the ores were worked at 120-300m. depth (400 - 1000ft.).

10.0 VEIN MINERAL WORKINGS
LEAD, FLUORITE, SPHALERITE, BARITE, WITHERITE

10.1 Zoning

The general zoning of these minerals, as described earlier, resulted in specific patterns of working of which that for lead is the most widespread and complex. Zinc, barites and witherite have relatively well defined limits where extraction occurred, which are generally exclusive, whilst fluorite and iron coincide with lead. In the case of iron, (See Chapter 5), interest combined where certain veins containing workable lead intersected the main iron carrying veins and examples are recorded of mines being worked for joint recovery or being re-opened for subsequent extraction of the second mineral. This coincidence is more marked in the case of economically extractable fluorite which occupies, as a matrix, those veins where iron was won but workings were separated temporally by virtue of the almost total demise of the lead industry before interest developed in fluorspar.

10.2 Extraction

Lead was first extracted in Roman times, although the initial priority in prospecting would probably have been silver, and recovery continued until the early 20th century, reaching its zenith in the 18th to 19th centuries. By the 17th century the most widespread deposits had been discovered and a degree of mechanisation had been introduced. Records up to this time are sparse,however, and tonnages are thought to have been small, perhaps in the range of only 100 tons per annum. Zinc, by contrast, was won only from the 18th century to 1965 and iron in a relatively short period from around 1880 - 1920. Witherite reserves were first worked around 1850 and are now virtually exhausted whereas fluorite and barite extraction began in the late 19th century and continue at the present time. Comprehensive records of the various mineral workings are included in

Economic Memoirs published by the British Geological Survey (Dunham, 1990).

10.3 Lead

10.3.1 History

The earliest dependable records (Surtees, 1820) refer to recovery from Bollihope, Stanhope and Edmundbyers about 1667-1677 with the ore being transported northwards to the staithes on the Tyne. In Teesdale the records pre-date this with ores from Eggleston, Mickleton and Holwick supplementing the main tonnages from the Yorkshire Dales which were taken southwards to Stockton-on-Tees. By the end of the 17th century sites at Blanchland, Muggleswick and Lunedale had been brought into production. The most important centre in Durham however, was Bollihope, although little in the way of Weardale ore was used as more lucrative resources were being worked to the south west. An attempt was made to compromise on these two locations by the construction of a smelter at Lunedale in 1756 but this only lasted until 1762. Until this time production had remained in the hands of multiple owners and extractive methods were relatively primitive at many small and scattered sites. Leases would generally be for a few hundred yards along a vein, extending 100 metres on either side with the ore being accessed from shafts or short levels. Alternatively the overburden was removed by "hushing", a process which involved the building of a dam above the area of interest and the excavation of a trench down which huge quantities of water were released thus creating the hushes, up to 30m. deep, which are such a feature of the landscape in parts of Weardale and Teesdale. The markets too had affected investment with dips in demand and a severe reduction, following the war of the Spanish succession in 1702-1712, resulted at times in almost complete cessation of supply and laying off the workforce. Tentative steps had been taken prior to this by the eventual major players to establish a presence in the area but it was not until the market revived in 1737 that large changes began to occur. From the 1750's better means of production were introduced with crushing mills, buddles, separators and slime recovery. Use of waterpower was expanded and more efficient smelting was effected with long horizontal condensing flues, although the disputes over the relative merits of simple ore - hearths and coal fired reverberatory furnaces continued more or less to the end of production. Production generally increased, with some dips, from 1750 to 1810 when a collapse was caused by the wartime depression, from which low point a revival occurred around 1820 which lasted to the 1870's and the industry thereafter struggled into the 20th century.

This growth and decline in markets paralleled the emergence of the powerful forces in the lead industry of County Durham, namely the London Lead Company and Blackett/Beaumont, later the Weardale Lead Company, and to a lesser extent the Derwent Mines Company which together dominated the scene from around 1760-1820.

Blackett and Beaumont's interest began in 1698 with the purchase of leases in the north of the mineral area at Allendale which were later extended into Weardale. No detailed records are available from this period until 1729, although it is known that smelting took place at Bollihope until 1750 and at Linzgarth, near Rookhope, which was constructed in 1737. From this time as the demand for lead grew the company began to rework mines which had been sub-leased during the barren periods. Records are available of 249,138 tons (Dunham, 1990) of lead concentrates being recovered in total between 1729 and 1817 from which point onwards individual mine records were kept. Major interests from 1820 have been stated as being Killhope, Sedling, Low Slitt and Boltsburn, with the latter two having a periodic overlap with iron extraction from the 1840's onwards. As prices fell in the 1880's due to a combination of competition from elsewhere and a severe recession, leases were surrendered and in 1884 the interests were taken over by the Weardale Lead Company which continued lead production until work at Rookhope ceased in 1931 from which time lead has mainly been produced in the orefield as a by-product of other operations.

The London Lead Company first took out leases on Alston Moor at Nenthead in 1692 and although an initial unsuccessful foray was made into Weardale, at Stanhopeburn in 1721, the company's main acquisitions and interests until the 1770's remained in the north, only affecting Durham at Ramshaw and Muggleswick in the north of the orefield where access to the Tyne staithes was easier. From 1771 more interest was taken in Teesdale and sites were leased at Lunedale and Eggleston where from 1771-1778 the Eggleshope vein was the most productive source for the company. In 1801 however the smeltery at Stanhope was leased and then rebuilt on the east bank in 1809 where it remained until demolition in 1886. Initially the ore came mainly from Ireshopeburn and Middlehope but exploration in Teesdale led to the opening up of the Coldberry-Redgrooves complex in 1812 where the Lodgesike-Manorgill site provided between 1816 and 1851 the bulk of the 122,420 tonnes of concentrates recovered. London Lead did not, initially at least, dominate Teesdale as Blackett/Beaumont did Weardale, having only six of 48 recorded mines in the area, but the company continued to buy out leases and open up new resources as at Flushiemere in 1827. When Lodgesike was exhausted in 1850 attention was transferred to Wiregill and further expansion took place at Revelin in 1854 and High Skears in 1862. A northern headquarters was established at Middleton-in-Teesdale and activities in the area kept the company profitable well past the general collapse of the industry in 1884 until final closure in 1905.

The two companies dominated the lead industry in the area for almost 200 years and although other smaller operators participated, the major part of the output was the estimated 20,000 tonnes peak per annum produced by the London Lead Company and Blackett/Beaumont (Weardale Lead Company). Although the main areas of lead mining may be identified in this way any analysis of working in a particular site cannot depend upon the records of the two large companies alone as there are many examples where different companies were involved at a particular mine for periods of time between the 18th.century and the present day, including the working of iron, barite, and the more recent extraction of fluorite (Rhodes, 1981).

10.3.2 Sample Area

Given the widespread occurrence of lead mining and the complexity of workings in any individual mine or group, a block of land, which can be considered typical of an area predominantly affected by lead extraction, has been chosen for more detailed examination in order to evaluate the impact of mining and to test a system of analysis which it may be possible to apply across the whole orefield.

The land contained within O.S. grids NY91-96E and NY26-30N in Teesdale (Fig 5.1) was worked for lead over a lengthy period from a number of locations, with seven main mines giving access to 13 major

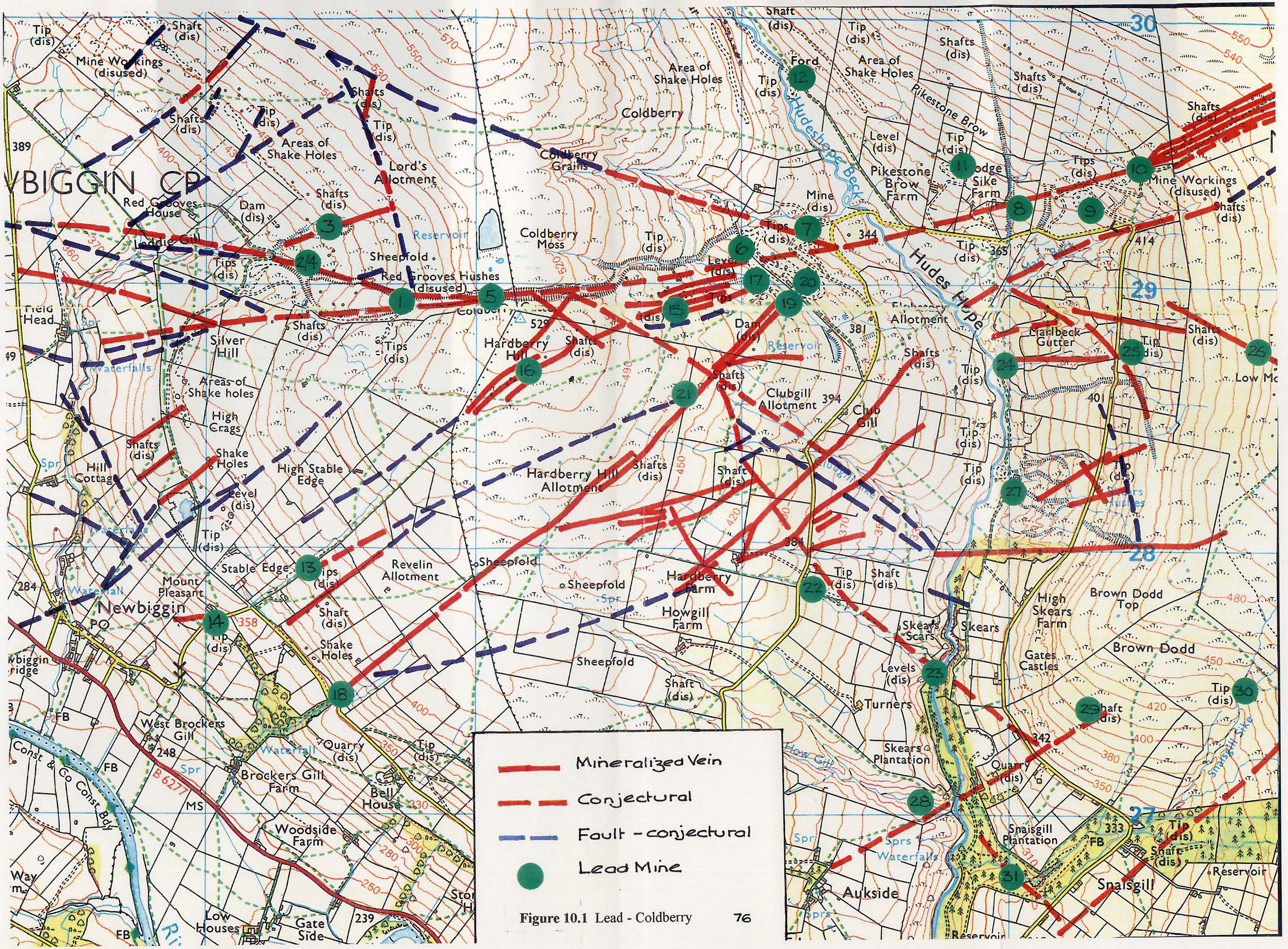


Figure 10.1 Lead - Coldberry

veins. The Lodgesike/Manorgill oreshoot was the main contributor to the output of the London Lead Company for many years as described in 10.3.1., with hushes, adits and shafts all used in the extractive process (Fig.10.1) (Table 11.1).

(a) Red Grooves Mine was worked from five locations. Two levels were driven at the west end of the gutter or hush running east-west along the vein, one north east towards the Hope Slit Vein and the second south east. The smaller open cut at Hunts Hush was dwarfed by comparison with the main Coldberry gutter which cut through the skyline of the ridge between the Bowlee and Hudeshope valleys, and remains one of the most spectacular examples of this type of working in the whole area although the success of the venture is not known. The mine was worked by the London Lead Company between 1852-1856, and tried by English Lead Mines Exploration Ltd in 1938/39.

(b) Coldberry Mine on the west side of the Hudeshope valley explored the group of mines to the south west of the hush from two levels but was not successful other than limited recovery from the isolated Lowes vein. The transverse hush missed the start of the famous and productive oreshoot which started some 530 metre east/north east of this point and was worked from Lodgesike.

(c) At Lodgesike Mine two levels were worked eastwards in the Manorgill Vein to emerge in the Eggleshope valley whilst an adit and a level were driven to access the Manorgill North Vein, which was also explored from Marlbeck to the south. The ores were exhausted by 1850 but from 1816 onwards produced the bulk of the London Lead Company's production in the area.

(d) Other veins trending east-west or north east are present between Red Grooves and Stable Edge along the outcrop of the Great Limestone at Newbiggin but are weakly mineralized. These include the Hungry, Harrisons, Wearmouth and Millhouse veins together with Stable Green which leads into Harberry Hill. This group was worked from two levels on the outcrop, and Harberry from a shaft sunk by R.W.Raine, which was used later, by English Lead Mines Exploration Ltd., to access the vein below the North Level of Coldberry Mine. Ventilation difficulties occurred and a solution was sought by driving to the vein from Skears Low Level. The Slate Sill Level to the north east also reached this vein which continues as Richardsons and was worked from a level of the same name.

(e) Ravelin(Hunts Coldberry) was the mine for the main vein in the area south of Red Grooves which was worked from a level on the outcrop and three levels on the west slope of the Hudeshope valley.

(f) Low Skears Mine utilised two levels, the Firestone and the Low Level which were driven to Hunts Coldberry and worked six minor veins en route.

(g) Marlbeck Mine was east of the Hudeshope Beck and from two levels and an airshaft reached a series of east-west and west north west trending veins which had originally been worked by hushing. Access was also linked to Lodgesike but it is not known how productive this operation proved.

(h) High Skears Mine was again on the east side of the Hudeshope valley, reaching Grahams Vein, Waltons Vein and Skears Old Vein from a level. Backhouse and Co. worked the mine from 1845 to1862 recovering 3890 tonnes of lead concentrates but the London Lead Company only produced 10 tonnes in the period from 1863 to 1881.

(i) Aukside Mine farther to the south tested the vein from a level on the west side of Hudeshope Beck but found only limited iron ore. Two more levels on the east side were equally unsuccessful.

(j) Snaisgill Mine produced limited tonnages of lead, barite and ironstone from two levels in the Holmehead and High Dike Veins between 1877 and 1894.

10.4 Fluorite

10.4.1 History

Although working was first attempted in 1854, at Crawley, by the Weardale Lead Company the genuine start of the Weardale fluorspar industry is held to be around 1882-1884, which coincided with the collapse in the lead trade, and indeed most subsequent fluorspar extraction occurred at former lead mines. The volume began to build up from 1908/09 and increased rapidly from 1948 when the major steel and chemical interests took up large holdings. All but two of the deposits which have been developed lie in the E-W trending veins of the quarter point group and within this, of the two million tonnes of crude ore extracted up to 1977, over 85% came from the Red, White, Sedling and Slitt veins (Fig.5.1). Because of the close similarities in the location of fluorite to other minerals in the quarter point veins and the use which has been made of former lead mines there is relatively little in the way of unique characteristics to the extraction of the ore and its impact on the mining patterns of the area. Of most relevance is the recent expansion and the way in which this may have rationalised some earlier undertakings. It is recorded that in 1985 there were ten mines producing an equivalent amount to that obtained earlier from the Weardale and London Lead Companies, with two central processing plants, and in addition two recently worked mines had closed (Fig. 10.2). These constitute the main areas of interest and the only other examples of mines reworked extensively for fluorspar are the original prospecting site at Hope Level, Crawleyside and Sedling Mine. Crawleyside is a particularly early historic case of attempted diversification where fluorspar was looked at in 1854, and again in 1882, before being worked from 1914 to 1932. After closure the mine was reopened in 1941 only to stop again when the ore became too silicaceous. In the case of Sedling the mine was worked originally for lead in the 19th. century but did not produce large quantities. It was however reopened by the Weardale Lead Company in 1900 to win fluorspar and by the time of closure in 1948 it had become the major producer in the area with over 166,000 tons extracted. Messrs. Hinchcliffe also mined fluorspar between 1926 and 1930 from an incline at High Sedling which was reopened unsuccessfully by the Weardale Company. In other locations fluorspar was extracted incidentally to lead mining but the quantities involved were not significant. By 1994 the County Council Structure Plan Review showed only one active operation and the treatment of the other, now abandoned, workings is a matter requiring further consideration.

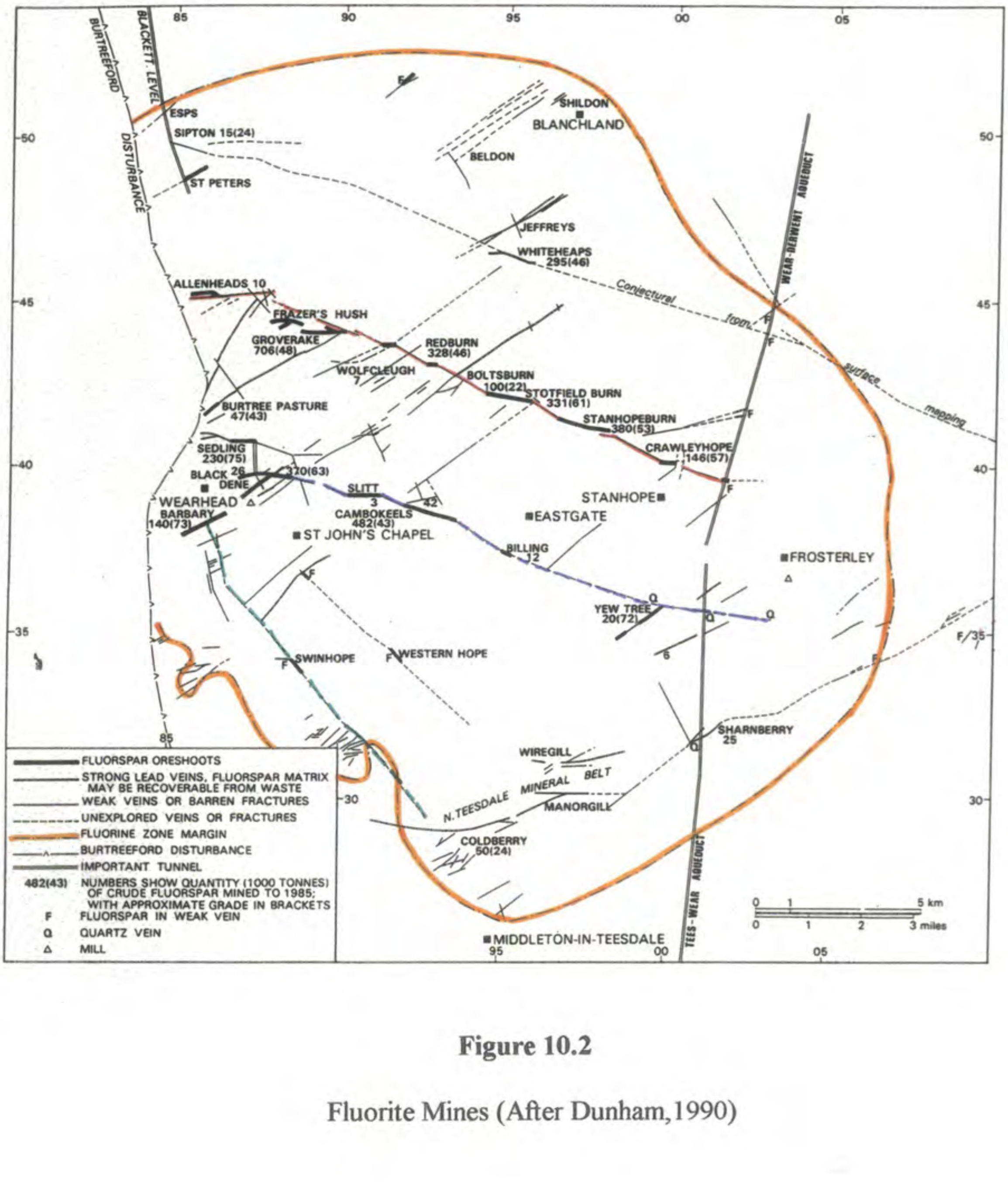


Figure 10.2

Fluorite Mines (After Dunham,1990)

Two of the mines only recovered spar from the waste heaps of earlier lead mining to be reprocessed at Broadwood. In the remaining ten mines the normal procedure was to refurbish the old shafts or levels and in most cases new levels were also driven or shafts sunk. The situation at Stanhopeburn is particularly complex as no less than ten companies operated the mine at different times between the 18th. century and the 1980's. It is this recent working and its overlap with current planning requirements, in particular the Minerals Review of 1981, which could determine the extent of any outstanding problems related to fluorspar extraction.

10.4.2 Fluorspar mine workings (Fig 10.2)

The main mines are described in Appendix 6.

10.5 Sphalerite

The main zinc ore, sphalerite (ZnS), is predominantly found to the west of the Burtreeford disturbance which therefore limits the occurrence of workings within County Durham. Early developments took place on the county border in the 19th. century at Nenthead and the surrounding region by the London Lead Company and its successors, the Nenthead and Tynedale Zinc Company followed by the Vielle Montagne Zinc Company. Although attempts were made to prove deposits in Durham only 182 tonnes were extracted from Weardale and 749 tonnes from Teesdale according to records up to 1985. There were three locations in Teesdale but none providing viable resources (Fig.5.1). Small quantities were recovered at Wynch Bridge (NY 9040-2791) in 1870, along with iron, which were good quality but too remote and limited to be economically worthwhile. A level driven at Dirt Pit (NY 8912-2902) in 1898 showed reserves which were too low in quality and although attempts were repeated in 1925 and 1940 no action was taken to develop the site. The Ministry of Supply sampled the source again during the wartime emergency in1941-1942 and proved 10% zinc but no development took place. The most serious attempt in Teesdale to produce zinc was from an adit at Willyhole Mine (NY8076-3327) worked between 1904 and 1908 but difficulty was experienced in separating the ore by gravity methods and the mine was abandoned in 1912.

10.6. Barite

10.6.1 Locations

Barium sulphate ore ($BaSO_4$) was first recovered from lead spoil heaps at the end of the 19th. century. Once again the limits of the productive zone, in this case lying beyond the fluorite core of the mineral field, dictated that the reserves in County Durham were located in a defined band. Although demand has remained fairly constant and has risen at times of war, only two areas, Cowgreen and Lunehead/Closehouse have proved consistently viable, with limited success at Langdon and Flushiemere (Fig.5.1). References to other deposits are found elsewhere in the area but these were mainly associated with the extraction of lead and did not prove viable. The mine at Lunehead remained almost continuously active, in respect of barite recovery, from 1884 to 1937 after initial development as a lead mine in the 18th.century and during this period it was highly productive. Further limited production took place up to 1981 but despite extensive exploration it appears the site is now exhausted and the main adit has been closed. South of the Brough - Middleton in Teesdale road a number of shafts were sunk and levels driven to work deposits which must have been shallow as evidenced by the numerous sink holes now visible.

More important reserves have been located at Closehouse where ancient large hushes were used to access lead deposits. The London Lead

Company then opened up the Deerfold Level under the Closehouse Hush and a second level within the main mine area in the period when they held the lease between 1770 and 1880. Limited production of lead took place until the site was taken over for barites extraction in 1939 and the mine level reopened with recovery starting in 1945 supplemented by some opencasting. Two further changes in ownership occurred but the mine continued to operate and remains active with over 300,000 tonnes of ore produced to date.

10.6.2 Cowgreen

The workings at Cowgreen were spread over a number of sites, primarily Dubbysike, Cowgreen and East Cowgreen and three companies were mainly involved, commencing with the Hedworth Barium Company Ltd. during the first world war, followed by the Harwood Mining Company and the Wrentall Baryta Company (Anglo Austral Mining Company Ltd). Dubbysike was originally worked for lead prior to the middle of the 19th. century and Hedworth then constructed a new adit for the extraction of both minerals, and Wrentall a shaft which appears never to have been brought into production. Some lead was also won from East Cowgreen but records are vague and the main interest in the area was barite which was won from a combination of shafts, levels and opencasting. Cowgreen was worked superficially by Hedworth but mainly by Wrentall commencing in 1935 from a new shaft and adit on the Winterhush vein which extended northwards opening up further levels and shafts. The Greenhush vein was similarly developed initially by Hedworth who reclaimed an old level, and the site was then taken over by Anglo-Austral who drove a new level. Records from the individual mines are not available, having been incorporated into figures for the Cowgreen complex, but over 300,000 tonnes was recovered in total before closure in 1952. The main Wrentall shaft at Cowgreen and the immediate surrounds were submerged under the water of Cowgreen reservoir in 1968.

10.6.3 Deep Mines

Barite has also been won in substantial tonnages from deep coal mines in mid-Durham, especially from a faulted zone in the Deerness valley to the east of the main ore zone (Fig.5.1). Deposits were discovered at New Brancepeth colliery in 1900 and developed between 1904 and 1921 during which period 117,659 tonnes were mined. The same mine was revived in parallel with Closehouse and Cowgreen in 1939 and until the pit closed in 1956, produced a total of 221,659 tonnes. Reserves were also proved at Lumley 6th. colliery (NZ 30-50) in 1941 but were never worked.

10.6.4 Witherite

There is no rational relationship between the occurrence of barites and the second barium ore of witherite ($BaCO_3$). This was first mined at Alston around 1850 but more success was achieved at deep coal mines especially at Ushaw Moor, in the same faulted zone of the Deerness valley, where 22,000 tonnes of barium ores, mainly witherite, was produced between 1921 and 1931 (Fig.5.1). Other mines in the same area were tried, such as Esh, Waterhouses and Wooley but without finding economically viable deposits. In mid-Durham the Craghead and South Moor area was also productive with 55,876 tonnes brought up at Morrison Pit (NZ 1734-5109) between 1932 and 1944. A special witherite shaft was sunk which has been taken out by opencasting following the closure of the pit in 1958 at which time over 237,000 tonnes had been won.

11.0 VEIN MINERALS - NEED FOR RECLAMATION

11.1 General

To assess the impact of vein mineral workings on dereliction, an examination must be made of the pattern of development for each ore, and put in the context of land use and accessibility, given the almost complete absence of any reclamation works.

11.2 Lead

11.2.1 Sample area records

Within the grid block NY91-96 E and 26-30 N there are 31 recorded features (Fig.10.1), related to the main group of mines, most of which are visible on the O.S.1/2500 sheets, although eight of the levels are shown in areas of tipping, which may mask the precise location of the entrances. In some instances the map reference given in texts, which does not exactly fit a marked feature, may be a misplot of the location as definite printing errors were discovered periodically. On five other occasions, plots of mines, although not showing workings, are consistent with the position of veins plotted onto the O.S. sheet and three are in areas shown as generally disturbed or related to tips. In only two instances is it impossible to deduce from O.S. maps that a mine could be present. The location of the mine is important in relation to the potential risk and preliminary examination obviously suggests that in some cases the remoteness of the feature from habitation or rights of way reduces the possible danger significantly. If an initial screening of the sites is done in this way, to be subject later to a fuller risk assessment, then the scale of the problem can be gauged in a preliminary way. In this area there are no mines apparently affecting built property and the assessment can therefore be limited to the proximity of footpaths, bridleways and roads. As an initial starting point the recommendation applied in respect of the Cornish tin industry, and the Derbyshire lead area, is used in that features in excess of 100 metres from access routes are ignored, using OS sheets at this stage (Table 11.1).

Number	Feature	Map Reference	On OS	Comments
Red Grooves				
1.	Hush	927-289	Yes	Remote
2.	Level	9239-2911	Yes	FP 110m.
3.	Hush	924-292	Yes	Remote
4.	Level	9237-2905	Yes	FP 110m.
5.	Opencast	9285-2895	Yes	Remote
Coldberry				
6.	Level	9399-2913	Yes	Remote
7.	Level	9425-2921	Yes	Road 80m.
8.	Hush	9500-2932	Yes	Ends at road
Lodgesike				
9.	Level	9529-2930	Tip only	Road 90m.
10.	Level	9550-2947	Yes	FP 20m.
11.	Adit	9481-2948	Yes	Remote
12.	Level	9421- 2978	Yes	On FP (Dead end)
Other Veins				
13.	Level	9227-2788	Tips	On FP
14.	Level	9203-2773	Tip	Adjacent road
15.	Level	9375-2891	Tip	FP (Dead end)
16.	Shaft	9317-2868	No	FP 70m.
17.	Level	9404-2902	No	In mine area

Continued Overleaf

Ravelin (Hunts Coldberry)				
18.	Level	9249-2744	No	Road 20m.
19.	Level	9418-2899	No	FP 10m.
20.	Level	9420-2903	No	FP 50m.
21.	Level	9378-2859	No	FP 150m.
Low Skears				
22.	Level	9424-2787	Tip	Adjacent FP
23.	Level	9469-2759	Yes	On FP
Marlbeck				
24.	Level	9499-2873	Tip	On FP
25.	Level	9546-2878	Tip	Road 60m.
26.	Airshaft	9591-2877	Yes	Remote
High Skears				
27.	Level	9502-2825	Yes	Adjacent FP
Aukside				
28.	Levels	9464-2705	No	FP 50m.
29.	Level	9530-2731	Yes	FP 150m.
30.	Level	9586-2751	Tip	FP 100m.
Snaisgill				
31.	Level	9500-2680	Yes	FP 50m.

Table 11.1 Lead Mines - Records

On inspection it can be seen that there are four levels shown on the O.S sheets which may cause a problem and an additional level shown as a feature but not defined as such. A further six levels are not clearly defined on the maps but are within tips or mineworking areas. Three levels and a shaft are not shown but could constitute a danger, giving a total of fifteen sites in all requiring further examination.

11.2.2 Other Mines

Within the designated block there are however many mines, or groups of mines, with shafts shown on the O.S. sheets, which are not referred to specifically in the most comprehensive record of the orefield (Dunham, 1990). Five of these could be classed as remote but thirteen appear from OS records to be either on, or within reach of, access routes. In almost all cases the origin of the working can be seen from their relationship to the vein system although some must, with the benefit of hindsight, have had little prospect of success. Ancient mining or unsuccessful trials may account for many of these sites, the condition of which is unknown (Table 11.2).

General Location	Feature	Related Vein	Situation
920-297	Shafts complex	Extension of Flushiemere	Some on FP
925-297	2 No. shafts/tip	Branch of Flushiemere	FP 40-50m.
924-293	2 No. Shafts	Extension of Red Grooves	Remote
924-289	Shafts Complex	Extension of Red Grooves	Remote
918-284	4 No. shafts	Un-named veins	FP 20m.
921-281	Level/tip	Un-named veins	Bridleway 100m.
924-278	2 No. shafts	Ravelin Old	FP 20m.
933-287	8 No. shafts	Beadles	FP 10m.
935-283	2 No. shafts	Hardberry Hill	FP 30m.
940-287	3 No. shafts	Ravelin	FP 70m.
940-282	Shaft	Raines	FP 20m.
938-290	8 No. shafts	Lowes	FP 70m.
946-287	3 No. shafts	Un-named veins	FP 10m.
945-279	Shaft	On Hall Level	FP 70m.
947-295	2 No. shafts/tip	Manorgill North	Remote
951-298	Shafts complex	Extension of Manorgill	Remote
958-296	Shafts complex	Extension of Lodgesike	FP 10m.
957-289	2 No. shafts	Marlbeck	Remote

Table 11.2 Lead Mines - OS Sheets

11.2.3 Observations

Consideration of the two processes of screening shows that neither is capable of providing, individually, a comprehensive or adequate analysis of the distribution of mine workings related to the lead industry. Many old features are shown on O.S. sheets which may only be detailed in old mine records, if available, but equally almost half of the mine accesses scheduled in the main descriptive source for the North Pennine Orefield are not shown or are unclear on O.S. sheets, and could not be easily recognised in this way. It may also be important that the latter tend to be mainly levels whereas the former are mainly shafts. It must be borne in mind that a line of "shafts" could be sink holes, formed where shallow vein workings have collapsed to the surface.

11.3 Fluorite

These workings have in general tended to be reopened lead mines and, as a result, have had relatively little additional impact on the incidence of dereliction in the area. Only 12 productive centres of any consequence are recorded although there was some recovery as a by product of lead mining. Of these 12, two were only concerned with recovery from old heaps and two were recent new mines covered by planning restoration conditions, leaving eight locations needing further consideration. The workings set out in Appendix 6 can therefore be put in different categories as set out below.

Old heaps:	Boltsburn Coldberry
New mines:	Frazers Hush Redburn
Refurbished lead mines:	Groverake Stanhopeburn
Former lead mines with new development :	Whiteheaps - An old lead mine with two pairs of shafts. The British Steel Corporation drove a new level post 1962.

Stotsfieldburn - A reconditioned lead mine. The old shaft collapsed and a new level was driven, worked 1957-1962.

Burtreepasture - The lead mine was abandoned in 1890 and refurbished in the 1970's. A new level driven in 1977 was abandoned in 1981. Once the best lead resource in Weardale.

Blackdene - A lead mine from 1818 to 1861. Originally worked for fluorspar from 1936 to 1939 and again in 1949. A new incline was driven to the surface in the 1960's by British Steel but closed in 1987.

Barbary - Formerly worked for lead from 1818 to 1872 but reopened with two new inclines between 1905 and 1934. Further conditioned and used between 1953-1959.

Cambokeels - Part of the complex with Heights, this was worked for fluorspar from 1906 to 1927 and again from 1935 to 1939. Reopened in the 1940's and again in 1970, a new incline allowed production until 1987.

As a result of the Town and Country Planning Act in 1947, fluorite extraction in Weardale and Teesdale was allowed under a general mineral permission and specific developments had conditions applied requiring restoration of the new facilities when these were abandoned. In the eight cases where former lead mines were reconditioned or extended the procedure for analysis and evaluation of risk can be identical to other lead mines with the advantage that an opportunity should exist to define the location and condition of previous entrances and workings in the vicinity of the mine through the details of the applications for fluorite recovery. Where reclamation or safety works are required and the mine is still in use, or has potential, then further conditions could be applied to achieve this although compensation would probably be payable. As with the mines for lead only, the necessity for works has to be evaluated taking into account risks to habitation or from public access.

11.4 Sphalerite

Working for zinc has had very little impact on dereliction in either valley with only 182 tonnes recovered in Weardale and 749 tonnes in Teesdale. Mining in Teesdale was confined to three locations, at Wynch Bridge (NY9040-2791), Dirt

Pit in Ettersgill (NY8912-2902) and at Willyhole Mine (NY8076-3327). Wynch Bridge had small quantities of good quality ore associated with iron but was considered too remote and limited in extent to be worth full development. At Dirt Pit a level driven in 1906 discovered ore which was too lean to be recovered by the simple gravity process in use at the time and works were abandoned until 1925 when another attempt again proved unsuccessful. In 1941 the Ministry of Supply re-examined the reserves due to possible wartime needs but, although ore with 10% zinc was proved, no further development took place. At Willyhole Mine the most serious efforts were made from 1896 to 1912 to extract zinc from an adit previously developed for lead but again separation proved difficult and only 712 tonnes were won. Two more levels were tried at the mine on associated veins which were only weak and uneconomic (Beadle, 1980).

All three entrances lie in remote locations and can not be considered to pose any serious concern. In general zinc deposits have resulted in surface workings and adits which explored limited reserves without significant impact.

11.5 Barite

11.5.1 Lunehead and Closehouse

The major reserves in the south of the area at Lunehead were worked from a main adit to the north of the Brough - Middleton in Teesdale road, accessing a series of eight veins to the south of the road where there were also three additional shafts, a level and many shallow surface shafts. A subsidiary vein to the north east, Hunters, was worked from three more levels, a hush and a shaft, whilst on the county boundary to the south west two more levels were driven and a shaft sunk to explore the Great Limestone but no records of output are given. In general all these features are in remote locations and unlikely to be a danger. The main adit is in the old mine complex, clearly visible, and the only two possible queries concern a level (NY8638-2058) described as "beneath Rennygill bridge" and a shaft (NY8535-2035) some 60 metres from the road. The second major source in this area, Closehouse Mine, was by contrast, originally worked by massive ancient hushes, still visible today, and subsequently from two levels driven in the same vicinity. When barite extraction started the main level was reopened and also extensive opencasting carried out. The mine is still active and inaccessible to the general public and hence not derelict nor a source of danger.

11.5.2 Cowgreen

The other main source of barite in the orefield, at Cowgreen, was worked from three mines, Dubbysike, Cowgreen and East Cowgreen (Fig.11.1).

(a) Dubbysike: At the western end of what is now the Cowgreen Reservoir, in a remote area crossed only by one footpath, the mine worked one main vein originally for lead, but subsequently for barite, starting with the Hedworth Barium Company in 1941. The old workings consisted of five features:-

1. Opencast (NY7965-3200) - on O.S.
2. Level (NY7960-3193) - not shown
3. Adit (NY7934-3160) - Possible misplot on O.S.
4. Level (NY7880-3162) - Two levels shown
5. Shaft (NY7862-3154) - On O.S.

The barite extraction was carried out from two new developments:-

6. Adit (NY7953-3194) - On O.S.
7. Shaft (NY7951-3198) - On O.S.

There is some lack of correlation between the information quoted in records, and that plotted on Ordnance Survey sheets. For example the adit (No.3) plots as a shaft with an adit some

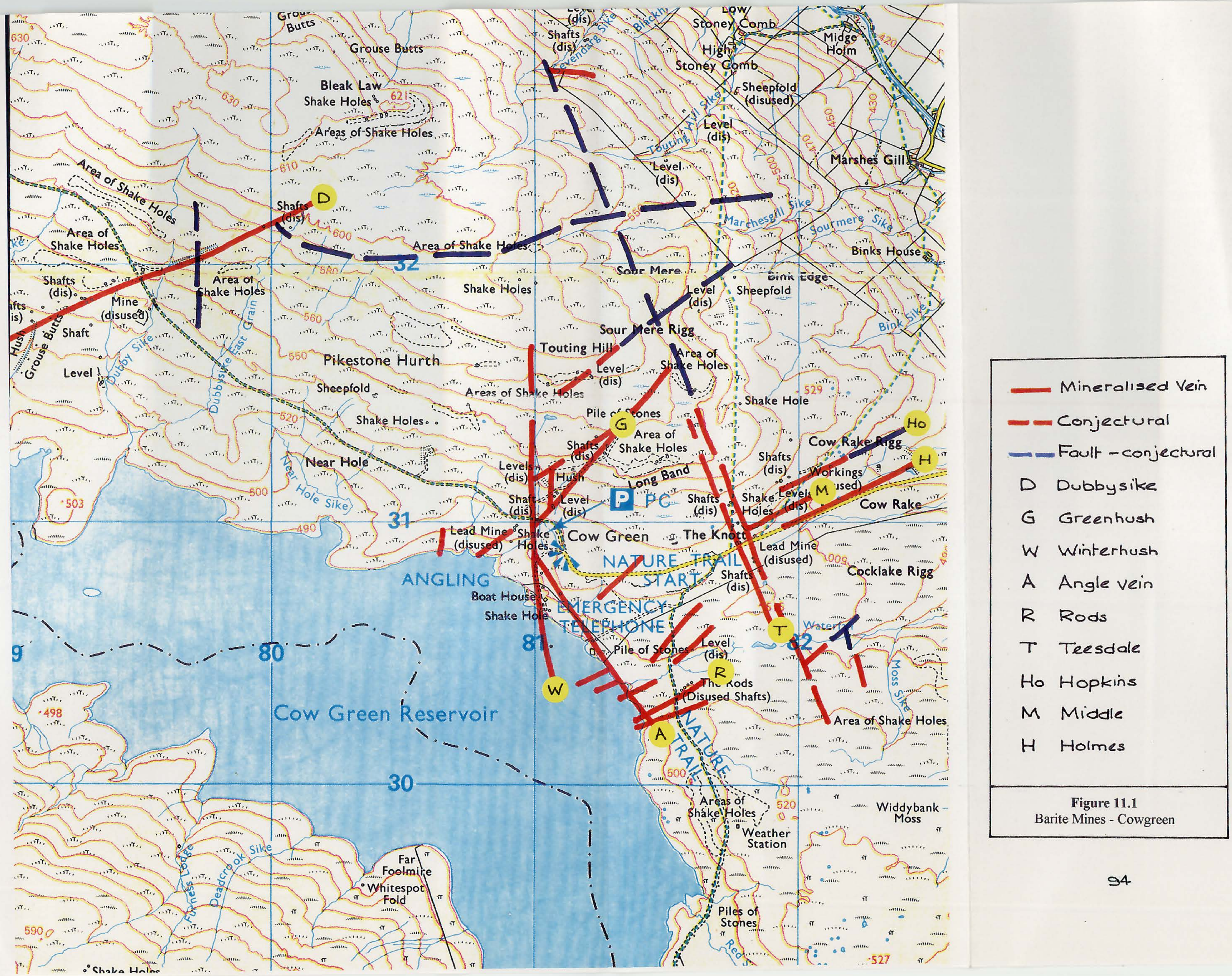


Figure 11.1
Barite Mines - Cowgreen

distance to the south. Between the south westerly pair of entrances (Nos.4 - 5) and the north easterly pair (Nos.1-2) a line of old shafts is visible on the O.S. map on the line of the Dubbysike vein but none come close to the footpath. Only the more recent barite mines are in close proximity to public access and should be examined, as the unrecorded disused mine shown is some 300 metres distant to the south.

(b) Cowgreen :- Mainly used for barite recovery after ancient lead working, this area was worked superficially by the Hedworth Barium Company and then by Anglo-Austral Mining Company Ltd. primarily from the Wrentall shaft, accessing the Winterhush and Greenhush veins. The original shaft (NY8105-3053) and adit (NY8106-3058) to the north have subsequently been drowned beneath the water of the Cowgreen Reservoir but a string of features remains, extending northwards along the Winterhush vein and north eastwards along the Greenhush vein. Correlation is again difficult but one shaft on the O.S. appears to be coincident with that shown on a longitudinal section produced by the Wrentall Baryta Company. Similarly a level plotted to the north (NY8106-3104) and two associated shafts may represent the Horse Level and associated shafts into the Greenhush vein. To the east of the main vein the Angle Vein was recorded as being tested at the surface but is shown on the O.S. as a shaft. (NY8115-3068). In total there appear to be five shafts along the access road to the boat house and a disused lead mine within 100 metres of the public footpath towards Dubby Sike. At a greater distance, but within reach of the public car park and therefore still of concern, are a level on the Winterhush vein and two shafts on the Greenhush vein to the north and north east respectively.

(c) East Cowgreen :- This mine worked a series of veins to the east, including Hopkins, Holmes, Middle, Rods and the Teesdale vein, resulting in a complex of shafts, levels and other workings as shown on O.S. sheets, very few of which are noted in descriptions of mining in the area. Only two levels in the vicinity of the Holmes and Hopkins veins are referred to specifically and match those plotted on O.S. sheets, at NY8236-3130 and NY8212-3120. A third adit, described as being at NY8229-3016, appears to be a misplot on the map or in the records but is almost certainly related to the same zone of exploration or extraction. The other features shown on the O.S. all consist of strings along the four main veins in the area which in each instance are close to footpaths or roads. The Teesdale vein appears to have six shafts or shake holes related to it, north of the main access road and a further three to the south, whilst the Hopkins and Holmes veins each have two shafts. To the south, at NY8199-3055 a shaft is recorded which is not shown on the O.S. but is thought to be connected to the working of the Rods vein, which is evident some 400 metres to the south west in a run of five shafts close to the Cow Green Dam access road.

11.5.3 Flushiemere

At only one other location , Flushiemere, does there appear to have been any serious attempt at barite recovery. Four levels, two hushes and a shaft were developed in the block NY9088-9157E and NY3010-3200N but the area is remote and the workings are unlikely to pose any threat. A postulated extension of the vein has been described in the assessment of the Coldberry lead area which concerns the string of old shafts to the south. In the Langdon area, shafts, levels and opencast workings on the Bands, West End and High Hurth veins were on a low scale and in remote locations. Only at West Binks do any public rights of way come into the proximity of mine features and the paths are hill tracks with evidence of usage.

11.5.4 Witherite

Production has been limited to that extracted in conjunction with coal from deep mines and only in one location did a feature occur, specifically related to witherite recovery, and this was subsequently taken out by opencasting. The impact on dereliction was therefore minimal.

12.0 VEIN MINERALS - PROBLEMS

12.1 Nature of Concerns

As with coal and iron/steel the difficulties associated with vein mineral workings divide into two categories, those related to physical conditions and those causing chemical or biological concern.

12.2 Physical

Mine workings leave a legacy of old shafts and drifts, together with spoil heaps and tailings and the usual range of surface structures. Shafts and drifts can be considered to have the same potential problems as with coal but dimensions tend to be less, generally less than three metres in diameter, reflecting the age of the workings and the nature of the extraction. Heaps are in general not as extensive as those for coal recovery, bearing in mind that the total tonnages extracted over the lifetime of the mines are only a fraction of a years annual output from the coal industry in the county. The heaps have not given rise to the same stability problems and, given the lack of movement, should be considered safe, taking into account the requirements for inspection under the Mines and Quarries (Tips) Act, 1969. Shallow workings exhibit the same physical problems as in coal mines but treatment is usually unique to each site due to the particular geology and circumstances of individual metalliferous mines. Leachate from tips or tailings lagoons is a possible environmental concern considered further below.

12.3 Chemical and Biological

12.3.1 Lead

Lead has been utilised in many different ways from early use in paint, armaments, as an additive to wine and in both glass and pewter. Its use in service pipes and other applications in house building became commonplace but it was the relatively recent discovery of the effects of lead as an additive in petrol which led to the wider public awareness of its dangers. Lead can be absorbed into the bloodstream where it affects the enzymes which produce haemoglobin. A build up of toxins can then occur, leading to such sicknesses as stomach cramps, headaches, disruption of the reproductive system and, in the long term, anaemia. Smelting can result in the presence of acids, spent oxides and smelter residues in the same way as with iron but the age of the industry in Weardale, Teesdale and the Derwent Valley means that only relatively simple methods were employed and although smelting does tend to concentrate contaminants, the residual problems of this method are thought to be less. Although different forms of furnace were tried much of the smelting began, and remained, with relatively simple open hearths, which were only really suitable for small quantities and smelting tended to carried out close to points of ore extraction. It was only in the development of long flues for the condensing of lead from the fumes that more sophisticated methods were employed. Some 20 smelting sites have been identified in the area, of which ten are in Teesdale, seven in Weardale and three in the Derwent/Muggleswick area (Rhodes, 1981). Although evidence is available, in the form of slag on the sides of the hush, to suggest some smelting at Coldberry, and reports of an early site at Newbiggin, the main activity near to the main area examined was at Blackton, or Egglestone Upper Mill. Research carried out by Professors Thornton and Maskall of Imperial College, London at lead smelting sites in Derbyshire and North Wales showed heavy surface contamination but little evidence of lead leaching into surrounding soils or polluting groundwater (Press report). Despite the nature of the hazards associated with lead any initial assessment should not therefore take too cautious a view of these sites.

12.3.2 Barite and Fluorite

The other vein mineral produced in any volume in the county, barium in the form of barite or witherite, is used in paint fillers and as a source of barium chemicals. Although safe limits are suggested in international codes for concentrations in soil or groundwater, tolerance levels are higher than for other heavy metals. Equally or more so, fluorite is seldom quoted as a potential pollutant.

13.0 COKEWORKS

13.1 History

Although charcoal was originally the heat source for the smelting of ores, from the early 18th. century coke began to replace this, due in part to the increasing difficulty in obtaining supplies of timber but also, as furnaces became larger, to the better inherent qualities of the coal derived material, particularly in respect of strength. The early coke ovens were simply open heaps or open boxes with a central chimney to improve the draught. As the Teesside iron industry expanded the demand for coke grew and "beehive" oven technology developed. These ovens consisted of a circular brick chamber with a sloping floor to allow the use of crude washers which reduced the non-combustible element before coking and hence the residual ash. Air was admitted during the process and extensive air pollution would be caused as the volatiles were burnt off to increase the heat within the dome. The scale of the works was, in general, small and as a result of the methods employed little pollution was caused in the vicinity (Lancaster, 1977). There was a recovery of heat from the waste gas but the process was inherently inefficient by comparison with the so called "Patent" process which succeeded it progressively from the early part of the 20th. century (Moyes, 1993).

Although there was resistance to change, a transfer gradually took place to the new process which had been developed, particularly in Germany, towards the end of the 19th. century. These ovens collected the coal gas which was used to heat the battery of ovens externally and from which tar and ammonia were then recovered. Earlier systems such as the Belgian Coppee type merely directed gases from above the charge of coal into the heating flues. Later models such as the Kopper also recovered by-products which consisted of ammonia liquors and tar, collected from the exhaust gases by flushing (Barry, 1985). Usable materials included sulphate of ammonia, benzole and napthalene, the production of which also generated effluents although phenols and light wash oils could be extracted from these as a secondary recovery. Where gas was to be taken into storage a scrubbing process was necessary to remove impurities. The agent used was bog-ore, a naturally occurring iron ore, which absorbed a complex mix of chemicals, and was successively re-activated by immersion in a stream of oxidising air until such time as the ore was "spent" or ineffective and therefore discarded. By this time the concentration of toxic constituents was severe, including complex ferro-cyanides which gave the so called "blue billy" its characteristic turquoise colour (Barry, 1993).

It can be seen therefore that it was not until the introduction of regenerating cokeworks in the late 19th. century that coke production began to leave a legacy of contaminated land.

13.2 Coal Sources

Coal is ranked according to its order of increasing metamorphism from peat up to anthracite which represents the most mature stage. In order to be suitable for coke production, coal should have the highest possible fixed carbon content commensurate with limits on sulphur and phosphorous, which cause difficulties in the smelting process. Increasing Rank numbers equate with an increase in the ratio of volatile matter to fixed carbon and an increase in the oxygen content of the coals. Reference numbers therefore progress from 100, anthracite, through 200's which are low volatile steam coals to 301, prime coking. Ranks 400, 500 and 600 are coking/gas coals, with the higher numbers of 700, 800 and 900 allocated to more general coals. The coke must be capable of withstanding crushing and abrasion in the furnace and of supporting columns of material up to 15m in height whilst not choking or sticking to the furnace lining (Wilson, 1973). The rank of coal is generally related to particular seams and whilst it is possible to add strength to a blend of lower grades by forming them into brickettes, the practice predominantly was to utilise the prime coking coal of rank 301. In the Durham coalfield this rank was at its best in the west of the county, progressing through rank 401, mixed coking and gas to a slightly lower grade 501 at the coastal collieries (Potts, 1976). As it was heat transformation caused by the Alston block which produced rank 301 in the west, so metamorphism has occurred in the vicinity of intrusive dykes in the east of the coalfield. At the Hett dyke the effect is limited laterally to less than 150m. and is not of major importance, whereas at the Ludworth dyke there is a marked impact resulting in rank changes in all seams up to three quarters of a mile from the heat source (Fig.13.1). The rank improves from 401/402 and 501/502 to 200H, 302H and 303H, the H signifying a heat changed material, and thus increases the coking capability of coals in all the related seams which were mined, particularly at Horden and Easington collieries (IGS, 1967). This has then influenced the distribution pattern of coke works in the county including their establishment in the east of the county where they would otherwise be unexpected, but where closer proximity to the ironworks on Teesside was an advantage. Records of cokeworks existing in the county at different dates show a changing pattern apparently reflecting the source of coal feedstock and the market outlets prevailing at the time which were related to the progressive reduction of iron production in County Durham and its gradual transferral to Cleveland (Moyes, 1993). A Ministry of Fuel and Power Regional Survey Report on the Durham Coalfield in 1945, identified seventeen cokeworks within the county and more beyond the boundary which used Durham coal. Of the main group, four were still apparently active in 1971 (Moyes, 1993) and to these had been added the new site at Hawthorn, but the remainder had closed since 1951.

When looking at these sites, it is advisable to separate out those major sites operating beyond the date at which the importance of gas and cokeworks was recognised in pollution terms. The sites closed since 1951 could have been

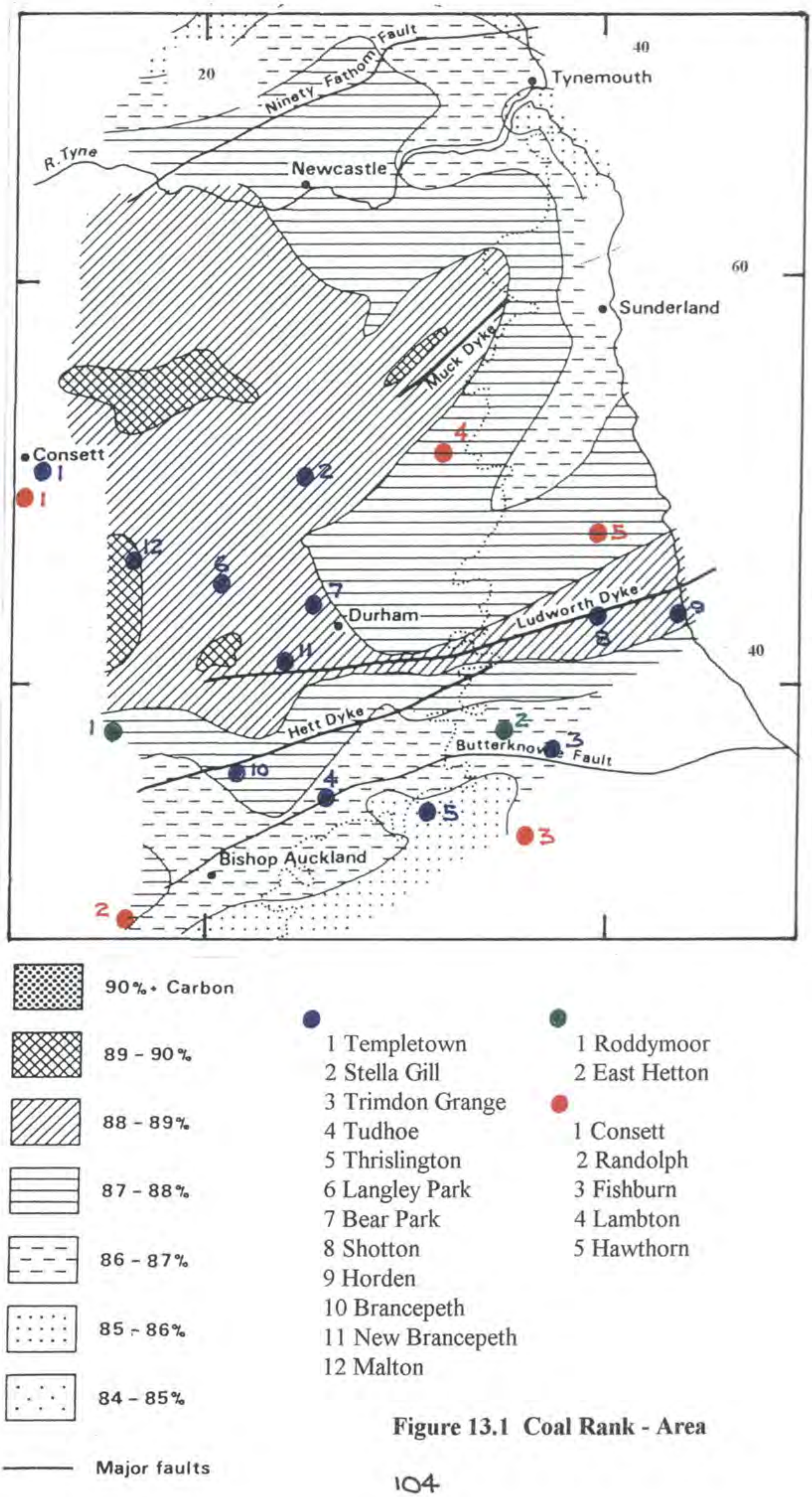


Figure 13.1 Coal Rank - Area

reclaimed prior to or following the issue of guidelines. The significance of this is set out on the following sections which also cover some additional sites identified in this study, and early beehive ovens.

13.3 Sites

13.3.1 Major sites worked recently (Numbers refer to Fig 13.1)

Consett Ironworks(1) at first operated beehive ovens but these were subsequently replaced by modern ovens, with the introduction of the first "patent" ovens in 1892 to give greater efficiency and these later included the recovery of by-products, from 1904_and 1924 respectively on the two different sites at the Fell works and Templetown. The Randolph(2) works were commissioned in 1895 using 60 of the Coppee type ovens which were increased by 20 in 1897. By-product ovens were introduced in 1909 and the original number of 50 was expanded to 65 and then by 1957 to 76. Once again the modern ovens had replaced earlier open heap workings and beehives dating from the end of the 19th. century at the nearby Norwood Colliery and other sites in the Gaunless valley (Walton, 1991). Fishburn Colliery Cokeworks(3) was a more recent installation which replaced the battery of ovens at Thrislington/West Cornforth. Similar recent constructions were at Lambton(4), on the county boundary, and at Hawthorn(5). Consett, Randolph and Fishburn have been reclaimed in the major derelict land programme but Hawthorn and Lambton sites remain although the works have been demolished.

13.3.2 Closures since 1951 (Numbers refer to Fig 13.1)

The 13 sites include Templetown(1) which was closely linked to the Consett works such that its development and reclamation followed that of the main Fell works. Eight other sites have been reclaimed and examination shows that four were dealt with prior to, and four subsequent to, publication of government guidelines relating to former gasworks (ICRCL, 1979) the implications of which will be addressed later. Those in the former category were Stella Gill(2), Trimdon Grange(3), Tudhoe(4) and Thrislington(5), all of which were removed in the general reclamation of the collieries although in the case of Stella Gill the works appear to have been in the scheme referred to as Newfield Coal Stocking Yard. Only in the case of Thrislington do records refer to by-products (Walton, 1991) although production again began with beehive ovens prior to 1871. New "patent" ovens were constructed in 1900 and further developed in 1914 with reference to tar distillation works which produced tar, napthalene, pitch and creosote. These lasted until 1954 when the modern battery of ovens was brought into use at Fishburn. From personal recollection some ovens exposed in the reclamation at Tudhoe were a simple construction and it may be be that development did not proceed beyond that stage as the colliery originally closed in 1935, although it subsequently reopened from 1941 to 1969. The later sites were Langley Park(6), Bear Park(7), Shotton(8) and Horden(9) where the main colliery sites have been reclaimed. Langley Park and Bear Park appear to have primarily supplied the Consett ironworks and operated from 1877 as beehive ovens. Although Bear Park was modernized and recovered benzole and tar from 1894, the ovens closed in 1916 (Madgin, Undated) whereas Langley Park was only converted to by-product recovery in 1915. This attempt at greater efficiency does not seem to have been effective and can be related to the investment which took place at Consett shortly thereafter. The cokeworks site, at some distance from the main colliery, appears to have received only limited treatment.

Four other sites require an individual approach. Brancepeth(10) is in a unique position as the coke works have been reclaimed but a by-products operation remained on the site. No official reclamation has been recorded at the New Brancepeth location(11) and this site merits further consideration. The remaining works, at Stanhope (Remote), do not appear on Ordnance Survey records and it may be that the reference could relate to production at Tow Law for the Stanhope ironworks or that the cokeworks were integral with the ironworks site. The only other cokeworks shown in the Ministry of Fuel and Power Regional Report of 1945 is at Malton(12) but it is not identified in the 1951 closures. From personal knowledge, tars and hydrocarbon by-products are present on the site and this may appear to indicate the past existence of a cokeworks, although subsequent use of the site for timber processing may also have contributed.

13.3.3 Other Sites (Numbers refer to Fig 13.1)

Evidence exists of other cokeworks, other than those shown as post 1951 closures, where by-products were apparently produced and they were therefore of greater significance than simple beehive ovens, the existence of which was widespread throughout the coalfield. The first recorded by-product ovens in the county (Warren, 1990) are credited to the Pease's operation at Crook in 1882, on the site of the Roddymoor Colliery(1). The colliery operated from 1844 to 1963 and was one of the first major reclamation schemes in the county when it was completed in 1968.

East Hetton(2) operated over a similar timescale, from 1836 to 1983, and cokeworks are recorded from 1880, when 50 ovens were in use, increasing to 101 in 1900. The dating of the development suggests the ovens would have been the "patent" type although no details are given

(Moyes, 1993). The site was reclaimed in two phases during the 1980's and 1990's.

An assessment of the impact of the large cokeworks suggests therefore that they are few and have little capacity remaining to cause contamination. Some by-product works were however reclaimed prior to knowledge of their polluting potential being widely available and clean up procedures may not have taken this into account. Two major sites are as yet unreclaimed.

13.3.4 Beehives

Examination of published literature from a wide range of sources suggests that the disposition of cokeworks in County Durham was far more widespread than shown in the supposedly definitive cokeworks plans although the type and significance of the earlier, smaller works put them into a different category of relevance from the larger and more recent centres of production. Beehive ovens, or unspecified early coke ovens, are mentioned at many locations including:-

1. Adelaide - shown mid 19th century
2. Croxdale - opened 1873
3. East Howle - on 1897 O.S maps
4. Hutton Henry - open 1871 to 1897
5. Leasingthorne - stated as beehive
6. Newfield - early O.S maps
7. Newton Cap - ditto
8. Page Bank - open 1855 to 1931
9. Rough Lea - early O.S maps
10. Sacriston - shown 1845
11. Shincliffe - early O.S. maps

12. Stanhope - on cokeworks maps
13. Tow Law - five of fourty six pits quoted
14. Tursdale - early O.S maps
15. Witton Park - with ironworks
16. Old Durham (Grant, 1971)
17. Framwellgate Moor (Grant, 1971)

It is reasonable to deduce from the age of many of these collieries as shown in mine records or on early O.S. maps, putting them before the end of the19th. century, that the ovens must have been simple beehive construction and therefore of less concern than those with by-product recovery.

Figure 13.2 Beehive Oven

14.1 Production

One of the primary reasons for the use in metal smelting of coke produced from bituminous coal is the removal of the volatile and viscous elements which would otherwise result in a binding together of the fuel within the furnace, thus hindering the free flow of air and the gravitational movement of the molten metal. A good metallurgical coke will contain up to 90% fixed carbon but less than 1.5% sulphur and only 0.5-2.0% volatile matter. Coke has the added advantage of a high crushing strength and should also leave only 5-9% ash on combustion. As approximately 0.47 tonnes of coke are required for each tonne of iron produced it can be seen that substantial quantities of by-products or waste result from the process of iron making (Barry, 1981).

14.2 By-products

Although the advent of natural gas from the North Sea and elsewhere has superseded the use of town gas derived from coal, the gas made available is utilised in the iron and steel making process to maximise efficiency. A similar purifying activity takes place giving rise to by-products which are generally the most important compounds in respect of potential contamination. A typical process flow diagram is shown in Fig.(14.1).

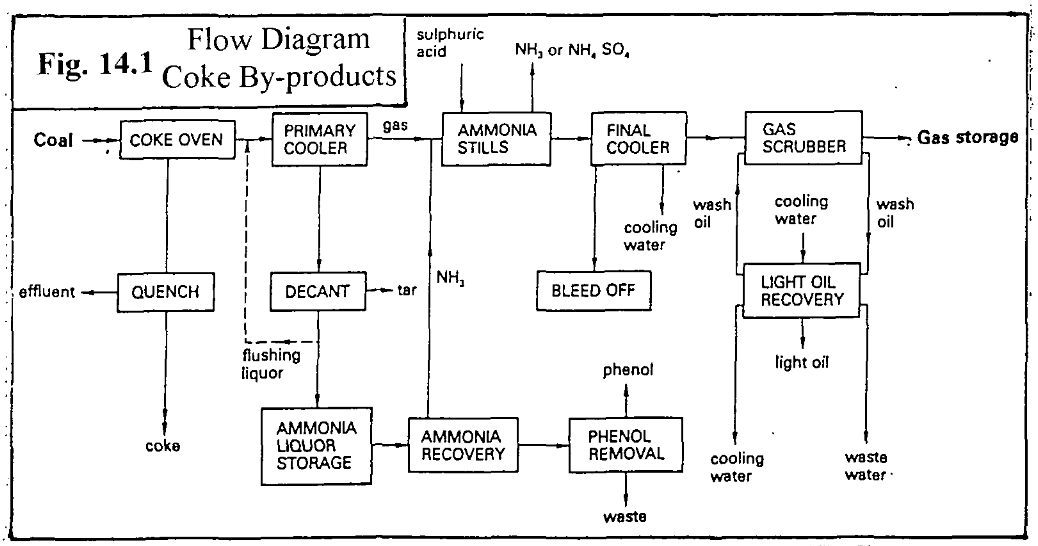


Fig. 14.1 Flow Diagram Coke By-products

Crude tar contains a variety of compounds and subsequent refining makes available phenol, toluene/benzene/napthalene together with pyrene/pyridine/ anthracines. The waste products from the cleansing process concentrate together some of the worst pollutants such as cyanides, heavy metals, phenol, ammonia and possibly thiocyanates. As with the earlier, simpler process producing spent oxide, a concentrated waste is generated and the by-products recovery can therefore result in the need to dispose of a range of potential pollutants in solid, gaseous or liquid form, which give rise to concerns over possible recipients if waste is not properly handled (Table 14.1).

Contaminant	Physical form	Potential hazard
Coal tars	Solid	Irritation,carcinogenic
	Solid and liquid	Combustion
Aromatics	Solid, liquid and gas	Central nervous system
	Solid, liquid and gas	Flammability/explosion
Phenolics	Solid and liquid	Central nervous system
	Solid and liquid	Corrosive
Ammoniacal solutions	Liquid and gas	Irritation/asphyxiation
	Liquid	Corrosive
Spent oxide	Solid	Irritation
	Solid	Combustion (cyanide)
Sulphides	Gas	Asphyxiation
	Solid and liquid	Corrosive
Free cyanide	Solid, liquid and gas	Acute toxicity
Asbestos	Solid	Asbestosis/carcinogenic
Coal and coke	Solid	Combustion

Table 14.1 Coke By-Products/Hazards

The compounds concerned are potential hazards, both physiologically and to construction materials, and include most of the major pollutants identified in studies carried out over the past twenty years. Exposure routes depend on the physical nature of the contaminant as set out in Table 14.1.

It can be seen that contaminants can exist in different forms and can also change due to physical conditions on the site. Vapours can develop from liquid forms and can then build up in confined spaces, whilst gases can be given off as a result of combustion, most noticeably in the case of free cyanide and hydrogen sulphide associated with spent oxides and sulphides. Asbestos can be present in various forms from uses such as pipe lagging, and is primarily a danger during demolition works. The waste water previously mentioned during consideration of iron and steel production emanates largely from the cokeworks and quenching water can contain proportions of phenols, sulphates, chlorides, ammonia and cyanides, well in excess of recommended international limits.

14.3 Receptor Mechanism

Contamination on cokeworks sites is similar, if not identical, to that on gasworks. The mechanisms by which receptors in these cases come into contact with pollutants can also be reproduced on other polluted industrial sites as set out below.

* Dust inhalation in dry and windy conditions, of carcinogenic material or PAH's (toxic - Polycyclic aromatic hydrocarbons)

* Breathing in of vapour from benzene or similar compounds.

* Direct ingestion when smoking, eating or drinking.

* Eye or skin contact causing burns (spent oxides) or carcinogenic effects (Oils/ tars).

* Combustion fumes from spent oxide (sulphur dioxide) or complex cyanides (hydrogen cyanide).

* Acidity from sulphates or oils/tars/phenols.

* Phytotoxicity from sulphates, some heavy metals, complex cyanides and oils/ tars.

15.0 BRICK CLAY, ROCK, AGGREGATES, WASTE DISPOSAL

15.1 Surface extraction of minerals and treatment of the voids and faces does not in general constitute a serious concern in reclamation terms. A brief review is required however as there are factors resulting from the quarrying which need consideration.

15.2 Materials

15.2.1 Brick clay

Brick clay occurs widely throughout the region and has been extracted by both deep mining and surface methods. Of special interest has been the fireclay associated with the coal seams which provided an additional resource, as a bonus to the primary mineral, again from both sub-surface extraction and opencast. The distinctive qualities of the material directed its use to refractory products, which were of particular value in relation to acid processes in the iron industry, and sanitary ware (IGS, 1971). In general however the fireclays could only be economically recovered if worked with coal, and both the quality and quantity were variable (Durham County Council, 1974). More usable brick clays occurred in the form of laminated clays of the Pleistocene age in large areas of east Durham although the distribution was spasmodic and not known with any precision. The laminated clays had the benefit of being stone free and also the characteristic of softening easily. Coal Measure shales are also suitable for brick production and have been worked in some locations. Each working was usually associated with a nearby brickworks as long distance transport of low value raw materials was inefficient (Durham County Council, 1974).

15.2.2 Rock

Surface extraction of different rock types has also been a prevalent feature of County Durham amongst which the most important has been limestone in a number of forms. In the west of the county the thick Carboniferous beds were the main source but the Namurian Great Limestone in Weardale was also important, providing material for a large cement works amongst others. In Teesdale opportunities are restricted by the overlying glacial drift and the geometry of the outcrop which limits the opportunities to pockets around Middleton-in-Teesdale and to the south of Barnard Castle (Fig.5.1). The rock varies in quality and whilst many of the Carboniferous limestones are suitable for aggregates, the Magnesian limestones in the east are only selectively used from the upper and lower bands, the middle band being softer and more porous. Limestone is used otherwise for roadstone and ballast, for lime production and in cement. Some, of particular purity, is suitable for use as flux in the basic iron and steel processes. The Magnesian limestone escarpment of East Durham between Pittington and Shildon contains some true dolomite with more than 40% of magnesium carbonate, suitable for use in the pharmaceutical, tanning, glass and textile industries (Durham County Council, 1974). This dolomite was also the raw material for the production of refractory bricks used in basic process furnaces and convertors. Other, more localized but useful, rock types are the particular type of Millstone Grit containing more than 97% silica, known as ganister, which was worked in parts of west Durham, and the intrusive Whin Sill in Teesdale. These are used respectively in the manufacture of acid refractory bricks, although to a lesser extent currently, and as high quality roadstone.

15.2.3 Sand and Gravel

Sand and gravel is found mainly as a result of glacial outwash, covering much of the lower ground in the county, although the quality is variable and the clay content is sometimes high. Alluvial sands and gravels are also worked along river terraces and the basal Permian yellow sands from below the limestone (Fig.2.3) between Pittington and Ferryhill (IGS, 1971).

15.3 Treatment

15.3.1 Rock, Sand and Gravel

Much of the derelict areas from these previous mineral workings, and also current permissions, lie in Areas of Great Landscape Value, as defined in the Durham County Structure Plan. Their impact depends largely on the height of the outcrop above the valley floor as many quarries were worked by an advancing face into the escarpment. Other than the visual intrusion of steep faces and old equipment on the quarry floor, these sites were not seen as high priority when compared to coal heaps (Durham County Council, 1974). Treatment has consisted of general removal of debris and machinery, followed by limited landscaping and access provision where a natural regeneration process can aid a return to acceptable conditions which are of ecological interest. Experiments are now taking place to accelerate these processes by analysis of the rock face and selective blasting to produce a smaller visible and stable face with scree below (Bailey & Gunn, 1991). Potential problems can vary as with the Whin Sill which intruded into limestone, sandstone or shale, leaving different conditions after extraction. The columnar jointing can also lead to toppling failures of old faces. In only limited cases have quarries been worked into the valley floor where they generally become water filled and a problem only in respect of the need to control access. Sand and gravel extractions produce similar conditions although the softer margins are easier to treat and landscape, resulting, particularly in the case of recent restorations, in good quality conservation or leisure facilities.

15.3.2 Waste Disposal

A potentially more serious problem exists in relation to surface excavations and that is the possible use of the void for waste disposal. It is known that infilling has taken place in some cases and the seriousness of the impact of this depends mainly on the date of the operation.

(a) Gas, Leachate. Until the 1960's domestic waste had a high ash content and although combustion was a problem the waste did not have a high proportion of organic material, added to which the rate of filling was relatively slow, allowing aerobic degradation to occur. From that period onwards however, domestic central heating became more common with a resultant drop in the proportion of ash, and the rapid growth in consumer spending led to the disposal of more general waste and biodegradable material. Landfill sites became larger and the rate of disposal accelerated rapidly. Recognition of the problems this could create led to regulations in 1972 controlling the disposal of hazardous wastes through the Control of Pollution Act in 1974. The Act was in response to the growing awareness of the difficulties posed by methane and leachate generation from the organic content of waste and was implemented from 1977. Methane produces an explosive condition when mixed with air in the proportion 5-15%. As with the Aberfan disaster, concerns grew with a number of incidents affecting safety, such as the explosion in a bungalow at Loscoe in Derbyshire in 1985, caused by methane from a nearby landfill site, but it has to be said that the incidence of life threatening events directly stemming from waste tips has been limited. The long term consequences of landfilling cannot however be quantified with absolute certainty and to guard against potential problems a series of Waste Management Papers was developed, covering all aspects of the industry from design and operation to monitoring and restoration. The most significant recommendation, although currently subject to critical review, is the presumption against new built development within 250 metres of a landfill site (HMIP, 1989). The regulations concerning landfill in the Environmental Protection Act of 1990 were brought into operation in 1996 and provide a far stricter regime in respect of monitoring, restoration, liability and the relinquishing of licences. Impending European legislation appears likely to strengthen control further especially in the case of co-disposal sites where mixing of materials could lead to unacceptable chemical reactions and the production of toxic gases or liquids.

(b) Records. Old claypits and brickworks in County Durham show a widespread distribution caused by the practice of local extraction and manufacture which dotted the county with small and large operations. Davison (Undated) has scheduled old claypits and works by area and these can be compared with records from the Waste Regulation Authority which has carried out a systematic review of working and closed landfill sites. Davison divided the county into lettered areas and a sample examination of the south west zone H, an early coal mining location, shows that 48 of 68 listed claypits or brickworks appear to be at, or associated with, collieries. Only five claypits are specifically identified and a further 15 could have involved extraction but are more probably concerned with production. Zone J in south east Durham, perhaps reflecting the presence there of laminated clays, has a lower proportion of sites associated with collieries, 23 out of 42 (Fig.15.1). Again however only five are clearly designated as claypits. Correlation between former claypits/brickworks and waste disposal sites, for this Study, shows there is little overlap. In south east Durham, Map J, only seven of the 42 sites could be related to landfill and all of these ceased working well before the start of 'modern' landfill. In south west Durham, Map H, only eight out of 68 could be suspect and only four of these continued until recent times. It can be concluded that brick clay extraction has had little impact on dereliction in the county, being mainly linked to the coal industry. In the cases where separate excavation has occurred only low risk surface workings were involved which have been restored with inert fill or have become water filled. The main risk potential comes from methane gas generation and major sites have been addressed by the screening operation of the Waste Disposal Authority. In particular locations where the voids overlie the Great Limestone or the Permian Yellow Sands, both of which are aquifers, then leachate could be a problem.

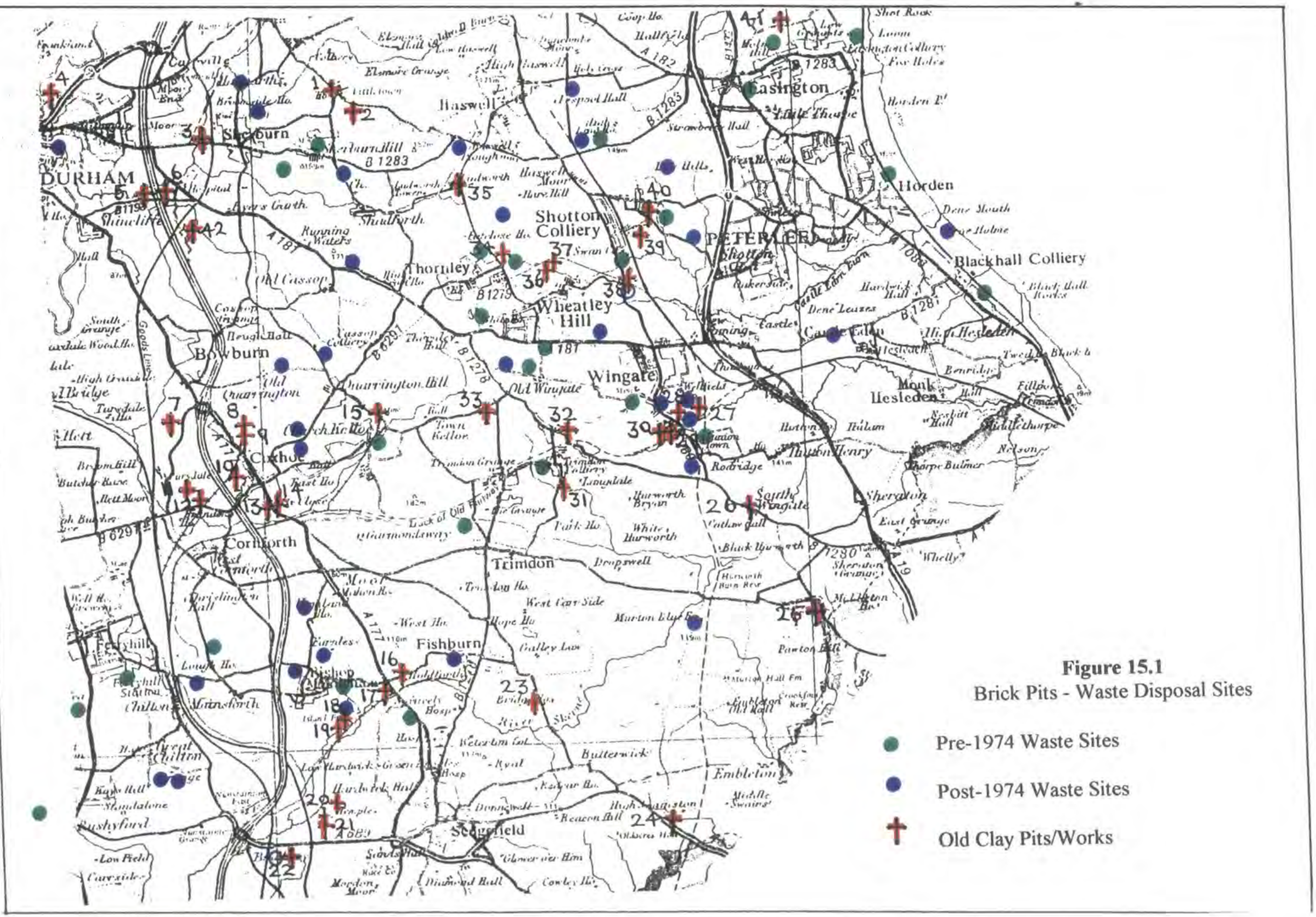


Figure 15.1
Brick Pits - Waste Disposal Sites

16.0 PROBLEMS, POLICY AND RISK

16.1 Risk Assessment

16.1.1 Nature of Risk

The approach to risk assessment has been suggested as a sequence of Risk - Policy - Evaluation or as Identification - Analysis - Response. The two descriptions however do not completely overlap and the strategies have to be combined to come to a sensible outcome in practical terms. Putting the sequence in more detail, the process consists of an initial addressing of the potential problems and derivation of an initial policy, followed by an assessment of the position and finally, a decision on a response. The sequence can of course be iterative as the initial response based on actual conditions can lead to a reassessment of the perceived position and an adjustment of the earlier conclusion. Risk is evaluated in a qualitative or quantitative manner but in either case the factors require judgement or weighting, and the parameters can be seen as subjective to a greater or lesser degree. It is this flexibility, which also enables economic or socio-political considerations to be brought into play, which permits the re-adjustment of a first decision. The search for an acceptable quantitative method has resulted in complex mathematical models but these are in general incapable of absolute proof and remain dependent on continuous revision of empirical data, which is as yet of insufficient duration or volume to be of real substance where derelict or contaminated land is concerned. The reaction of the insurance industry, which has contemplated the problem for some years without reaching firm conclusions, bears this out. The seemingly arbitrary or erratic nature of incidents which can be caused by mineral extraction or subsequent processing has resulted in limitation by insurers of the size or number of claims which can be covered, and much more work will be required before generally accepted standards can be agreed.

16.1.2 Evaluation

The following evaluation of the risk posed by features examined in the desk studies and field observations of mineral working in County Durham therefore starts with an initial, primarily qualitative view, formed against the background of existing government policy. Efforts which have been made previously to quantify risks generally are then reviewed before applying similar basic methodologies to the evaluation of risk in these particular cases and arriving at decisions on responses to the problems present.

The problems which can occur in derelict or contaminated land have been set out in preceding chapters on individual minerals or processes. These problems fall into various categories, including visual, physical and chemical or environmental, and have been described in the sections covering individual minerals. Visual intrusion is not strictly a risk and previous policies have in any event been largely successful in this respect in addressing and treating the impact of derelict sites. Further decisions need therefore only be concerned with a review of whether or not changing standards and developments in fields such as tourism merit a revision of previously accepted criteria. The second consideration is that of physical conditions on a site and the dangers or difficulties which these can cause. In this case the problems can be visible or hidden to a greater or lesser degree but the balance is still on the side of a discernible problem. Surface or shallow workings, mineshafts or adits, and construction remains, all contribute to the potential risk. In the third category the emphasis moves to that of hidden problems since environmental pollution, although sometimes visible, is more often not at all obvious and requires a knowledge of the former working process, and usually thorough site investigation, before any risk can be inferred or confirmed.

The mechanism by which interaction occurs with a receptor however, depends upon particular circumstances at each location and it is at this point that the evaluation of risk begins. Accessibility, ground conditions, the age of the works and use of the site all affect the chances of environmental damage.

Consideration of the above provides the information necessary to develop general policy which should ideally contain explicit methods, limits and standards. These may however be unable to guarantee that the primary objective of avoiding "damage" to human health or the environment can be met, noting that "damage" is in itself a qualitative term. Other factors too are brought into consideration as has been demonstrated by the almost continuous attempts over the past twenty years to determine a consistent and acceptable policy for contaminated land. Engineering, physiological, legal, financial and political judgements are all factors which can influence the final outcome.

Application of the accepted policy, to the particular circumstances of a site, brings into play all the factors above and particularly the question of funding, as any meaningful assessment of a site will require a thorough desk study and possibly actual site investigation. The initiative for doing this may come from the Environment Agency or the local authority, or it may be required of the site owner/operator or a previous user. In the event of the site appearing to be in need of reclamation, legislation may require the same agencies to take action and in the absence of fixed standards, variations in treatment are possible.

The final outcome should be a coherent strategy which is capable of being implemented, able to be modified in the light of changing circumstances and acceptable to those charged with responsibility. The extent of remedial works required should not be a primary limiting factor but in practice it is unlikely, given the partially subjective nature of risk assessment, that anything other than a measured and phased response would be acceptable. Different agencies adopt stances which have to be reconciled, as national government, European law and standards, local government and industry interact to sway the balance of what is acceptable at any point in time.

16.2 Current Strategy

16.2.1 Government approach

At a conference in London in1994, the basis of the governments thinking on Risk Management Strategy for Contaminated Land was set out (Denner, 1994). In their view the process should begin with identification of hazards, identified through potential sources listed in Industry Profiles. Preliminary analysis then considers the likelihood of a significant occurrence, persistence in soils and toxicity to humans, and finally the impact on the water environment, plants or animals, and buildings or materials. It was stated that the government was contemplating a scheme for prioritising and categorising sites using screening and an initial visual inspection. The next stage in estimating risk would involve a more quantitative approach using site investigation, the characterisation of hazards/pathways and the possible development of mathematical models. The evaluation of the risk, taking into account toxicological information on soils and better research into pathways and leaching, led to the intention to issue "guideline action values". These would be influenced by existing water quality standards, current construction industry criteria and guidance which was yet to be provided on the ecosystem. Risk management should be on a site by site basis. Caution was expressed however, stressing that the subject required understanding and that primary legislation was usually qualitative. The government departments were continuing to work with other countries, engineering and scientific institutions, industry and landowners. Work carried out by independent consultants at about the same time, directly on behalf of the Department of the Environment, reinforced the view taken by advocating a three stage process of a map based assessment, followed by a desk study/site visit and finally more detailed investigation leading to the establishment of four levels of priority (Carter, 1994).

16.2.2 Other Views

Discussion at this time and development of systems by several agencies confirm the interest in establishing a practicable method, if possible. Work carried out in Australia reached more or less identical conclusions in respect of qualifying factors and ranking systems (McFarland,1993). The view was expressed by more than one contributor at the time that the ranking method depends on the requirements of the originator and the proposed use of the site, thus tending towards the "suitability for use" concept. The British Standards Institution Draft Code of practice for the identification of potentially contaminated land and its investigation (BSI, 1988), suggests for example that priorities can be reversed quite easily. What would be high risk, such as gardens or food production, in respect of material injurious to plants or humans would be low risk under hard surfacing. If methane gas production were the problem, the priorities would be reversed and surfacing with migration pathways to buildings or services would be the greater risk. In an attempt at greater consistency, analysis carried out for the Government Agency, Scottish Enterprise (Hart, 1996) used the normal starting points of hazard (contaminant) and environmental sensitivity (pathway and receptor). Value and weighting were then allocated to the seven hazards and nine sensitivities, leading to total scores which could then be grouped in categories. It has been said that any clients tailor made ranking system can be modified to suit anothers requirements, and this can clearly be done here by modifying the values and weightings. The factors therefore remain subjective to some degree. Attempts were also made to apply the principles to visual considerations but even the Agency stated that although "based on general assumptions ... [they] ... relied on subjective judgements".

16.2.3 Discussion

An interesting light was thrown on the discussions by an article, and subsequent correspondence, in the Proceedings of the Institution of Civil Engineers (Wood, 1994, Barry, 1995) entitled "Debate: contaminated sites are being over engineered". The proposer suggested that by use of the hazard and sensitivity philosophy put forward by the Construction Industry Research and Information Association (CIRIA 1995) it would be possible to avoid the massive costs and litigation expense incurred in the United States by their state funded programme. Reference was made to the way in which ICRCL "threshold" levels had gradually become "action" levels and cover layer or break layer thicknesses had increased without justification. The author did at the same time regret the lack of progress towards final recommendations on soils and the absence of any guidance on groundwater contamination. The opposer of the proposition referred to the generally widespread view that ICRCL levels were "a best guess in the 1980's to promote discussion" and to the fact that health hazards were unquantified. The problems of asbestos had been underestimated for too long before action was taken and protection against multiple hazards and pathways were too little understood. He believed it is possible therefore to argue for an all encompassing, failsafe solution, bearing in mind the incidents at Lekkerkerk in the Netherlands and Love Canal in the USA, where real damage had been caused. Accepting however the differences on sites underlain for example by an aquifer or solid clay, it would be better to adopt a tailored response, based on risk assessment, which must be cautious and rigorous. In the ensuing discussion more than one reply stressed the need to define the scale of the hazard and the effectiveness of solutions, taking into account the uncertainty of toxicity knowledge. Engineering factors will always result in over-design but this has to be a wise precaution in view of public perception, institution funding and environmental regulations. Developers inevitably want to have a total clean up, but some consultants, believing the present ICRCL guideline levels should be interpreted realistically, see developers and the insurance industry as too cautious. In response, the proposer accepted that contamination is present and that protection must be provided to satisfy a level of confidence. Even with value judgements to be met, there is a need to reduce the unknowns and a combination of more research with thorough risk assessment appears to be the right way forward.

16.3 Existing Policy

Developed from the above therefore, present Government policy is based on the principle of "suitability for use" which was confirmed in the "Framework for

Contaminated Land", issued by the Department of the Environment in November 1994, and described as the outcome of the Governments Policy Review and conclusions from their Consultation Paper, "Paying for our Past". This proposed that only where contaminated land poses unacceptable or potentially unacceptable risks to health or the environment, and there are appropriate and cost effective means available, would remedial action be required. The objectives were set out as :

* The improvement of land to deal with hazards
* Encouragement of an efficient market in land
* Encouragement of development
* Removal of financial and regulatory burdens

It was intended that these objectives would be achieved by a combination of voluntary action, public sector support, planning control and building regulations, direct regulation and control, and use of the common law. A hierarchy of supervisory control would be established with the newly created Environment Agency providing technical expertise as well as advising on policy and priorities. The District and Borough Council's responsibility would be directed to the identification of problem land and achieving action on site. In either case initial responsibility must lie with the person who originally caused or knowingly permitted the pollution or damage to occur, under the "polluter pays" principle. Regulatory liabilities were proposed as the instrument under which action could be enforced or costs recouped. A notable exception appeared to be possible through continuation of freedom from prosecution in the case of discharges from abandoned mines, and the recent clarification, through establishment of case law, of liabilities in respect of some aspects of common law was recognised. The next major advance in the development of policy came with the issue, through the Department of the Environment, of the Governments "Consultation on Draft Statutory Guidance on Contaminated Land" in 1996. This repeated the precautionary principle based on the concept of land being made suitable for a specific use, rather than a full all-purpose clean up, and this was clarified as applying to current use of the site. It is proposed that local authorities remain primarily responsible for inspection and regulation whilst, for the first time, the definition of relevant land embodies the principle of risk assessment. This definition of land at risk introduces the concept of "significant" harm being caused or becoming a possibility, together with instances where pollution of controlled waters is being, or is likely to be caused. More detail is provided in each section. Local authorities are required to inspect land in their area in accordance with the definitions stated, and may take into account development on land which predates relevant current guidance but where problems may exist. Advice is given on specific categories of former use designated as Special Sites where other agencies must be consulted or given responsibility, and emphasis is placed on the risk assessment concept by stipulating that consideration must be given to linkages between pollutant, receptor and pathway. The authorities are directed to published information on risk assessment techniques but at the same time it is recognised in the document that guidelines on toxic effects and procedures, although the subject of research, are still not available. The chapter on definition provides more detail on risk and how probability should be combined with magnitude to establish the importance of a situation. Much attention is given to the interpretation of the word significant, which is critical to a site being classified as contaminated. Tables are provided to assist, which allocate descriptions of harm to various receptors such as human beings, living organisms, livestock and property, taking into account in Table A the immediate effects and in Table B those which could be assumed to occur over the lifetime of the authority (Appendix 7). Remediation which the enforcing authority may do, or require to be done, is limited by a reasonableness clause in respect of both cost and seriousness. Although regard has to be taken of guidance issued by the Secretary of State, it will be recalled that some guidelines are still being worked on and where trigger or action levels have been issued they are far from a complete reference schedule of possible contaminants. Despite these difficulties, authorities are expected to take account of reasonableness, effectiveness, probability, practicability and efficiency. Monitoring should be undertaken where long term effects may be present. The penultimate chapter, followed by one on recovery of costs, covers exclusions and liabilities. Persons responsible are placed in one of two categories, being the originator of the contamination or the subsequent owner of the site. In each case possible exclusions are defined which prevent or limit liability. The policy to be adopted, unless altered dramatically during consultation, appears likely to constrain the terms under which remediation can be justified but has to be taken as the starting point for any investigation.

17.0 POLICY AND TREATMENT - SPECIFIC SITES

17.1 Extent of Problems

17.1.1 Coal

The first case examined was coal, which was assessed by means of two sample areas, taken as typical of two different parts of the coalfield.

(a) O.S. Sheet 33 was selected in the western area which, although containing many old abandoned mines, had also been heavily opencasted, resulting in far fewer sites potentially requiring remedial works. Initial screening by name alone suggested 15 mines or groups which appeared to be worth further examination and closer inspection of old O.S. maps revealed that these contained in all 37 features (Appendix 3). From a primarily visual point of view only one site was included in the local authority's schedules and this was classified as not justifying reclamation. Two other sites however, identified in this review, are in close proximity to housing and public access routes and should be considered for treatment, even under the original policy. In none of the cases could stability of the heaps be seen as a major problem. From a safety point of view, taking into account the other potential dangers posed by old mine workings, risk clearly relates to the presence of a receptor, and this is then dependent on the proximity of buildings or on public access being available. Of the 37 shafts and drifts identified only one could be clearly thought of as being a risk and this has obviously been realised by the local authority with safeguards being put in place (Figure 17.1).

Figure 17.1 Coal Shaft - Footpath

Remedial works or a footpath diversion will ultimately be required. Although other examples are present of shafts in quite close proximity to footpaths, these routes are little used and can be considered as low risk. The farming community is generally very efficient in monitoring the condition of their land and it is likely that any movement or danger will become apparent to them before the general public. Given the guidance in Table A of the governments consultation document that only a 10% loss should be considered significant in respect of stock, the risk relating to those sites in ordinary agricultural locations has to be put as low (Figure 17.2).

Figure 17.2 Coal Shaft - Agriculture

With regard to property, only three sites are in close proximity to housing or other buildings and all appear to be in areas of open space although nothing of the former works is visible on the ground. It is likely therefore that the developers and subsequent owners, as well as the planning authority, have been aware of the potential risk and have controlled building layouts accordingly.

(b) O.S.27 was selected as an example of the central area of the coalfield, where initial screening by name alone produced only eleven mines, none of which had subsequently been opencasted. Three references to shafts and drifts in Parish records, one of which was later opencasted, and three additional sites identified on O.S. sheets, resulted in 16 locations, having a total of 28 features (Appendix 4). Entries under two further place names were not site specific but appeared to be generic, covering multiple mines or groups which were individually listed elsewhere. As might be expected from past local authority policy, in an area containing the A1(M) motorway and the East Coast Main Line railway, as well as the fringes of Durham City, none of the sites are significant in visual terms. There are no situations where unprotected shafts or drifts lie in close proximity to public rights of way although two shafts are situated in a National Nature Reserve where access is possible. The shafts at Houghall and on the riverside in Durham have been protected and have visible features, leaving only the shaft at St. Oswalds, which is now on a golf course, with a slight question mark against it. As with Sheet 33, the features in agricultural land do not pose any current problems and surveillance by the farming interests should ensure this continues. Specific mention should be made however of a pair of shafts at Whitwell, now under a substantial mound, which had been supposedly made safe. The fill collapsed dramatically overnight in the 1960's (Personal communication from the farmer) requiring the then National Coal Board to carry out urgent and extensive remedial works. The possibility of a sudden collapse many years after filling is therefore emphasised where adjacent activity can be a trigger factor, perhaps in this case the construction of the near by A1(M) motorway. With regard to property, there are only four locations where there could be concern. The shafts at the University Library have however been treated by capping (Grant, 1971) following a partial collapse of previous fill leaving a void recorded as almost seven metres. Two sites are within hard surfaced compounds and any remedial works should have been carried out with development of these depots. Only one shaft appears to be in the vicinity of housing and should have been treated accordingly. As with the sites in Crook, referred to in the O.S. Sheet 33 section, the location has been left as open space, suggesting the developers were aware of the potential danger.

17.1.2 Iron

The second category examined was iron extraction and processing, taking ore mining in the vicinity of the Red Vein as a typical area and, in respect of processing, looking at the totality of iron and steel production in the county.

(a) Of the 73 mines identified initially in the complete area of Weardale and Teesdale, only 23 appeared to have any real potential to cause concern, visual and tip stability considerations having been largely discounted in the assessment of problems carried out earlier (Appendix 5). Equally, it has already been stated that iron ore remains are in themselves not a contaminant hazard. Further examination therefore concentrated on the physical problems of mine entrances and this reduced this number to 16 by refining the risk criteria marginally. Of these, half lie on or near to the Red Vein. Seven sites are in the relatively compact area between the village of Rookhope and the end of the valley as it climbs to Allenheads some seven kilometres to the north west, and this therefore represents a good indicator of the impact of ironstone mining. Of the seven possibilities, three drifts (Sites 8b, 9a and 9b) are in quarries or disturbed ground and are not identifiable on site. As none are directly on public rights of way or are otherwise accessible any human receptor route appears to be very low risk and stock risk on a moorland area is equally unlikely. One level of the remaining four sites is in a works area and not easily approached (Site 5c) and a reopened lead mine is also in private property. The shaft and drift remaining have differing degrees of risk attached to them, based on the probability of access, which was reviewed in the light of weighting relating to frequency of use of the public rights of way in the area, provided by local authority staff closely concerned with countryside and leisure matters. An exercise carried out as part of this study demonstrated that classification of footpaths by usage is a quick and simple exercise and can provide a means of refining the risk potential of derelict sites. The shaft (Site 2a) although clearly visible and with only a poor fence protecting a loosely fitting metal cover, is not a high risk despite it being situated only some 40 metres from a footpath as the route is classified as having the lowest level of usage (Figure 17.3).

Figure 17.3 Iron Mine - Cover

The drift on the south east bank of the river (Site 5a) is not a high risk with the entrance clearly visible but it does lie on a footpath designated as having the highest local use. The mine water issuing is clearly polluted with evidence of staining (Figure 17.4).

Figure 17.4 Drift Entrance - Iron

Examination of the site also produced a clear example of the problems which can exist in such a complex mining area. In the vicinity of the drift is an engine house shaft which, although almost on the line of the Red Vein, was in fact the main access to Watt's Level serving the Boltsburn East Mine on the north east side of the valley, which was primarily worked for lead. As reserves in the vein were not exhausted when the deep workings were allowed to flood in 1932, consideration was given to reopening the mine and this led to Watt's Level being kept pumped out until the 1950's (Dunham, 1990). The shaft was apparently filled, but the quality of the work is unknown, and there is only a poor quality fence to deter access to the 54 metre deep shaft and its inadequate timber cover which vandals have attempted to burn. The shaft is immediately adjacent to the 'Rookhope Trail' which has a top classification in terms of usage and there must therefore be a reasonably high degree of risk attached to this site (Figure 17.5).

Figure 17.5 Lead/Iron Shaft

(b) Of the ten recorded ironworks in the county, those at Consett, Tow Law, Tudhoe and Ferryhill, have been reclaimed and two, at Darlington and Seaham, were primarily involved in cold metal processing. Whilst the latter can give rise to problems, the Darlington site has continued to be active and any current consideration would have to take into account the intermediate and present uses. The Seaham site was within the curtilage of the Dawdon Colliery complex and in view of both its past use and current reclamation treatment should therefore be a low risk. Whitehill was an ancient furnace, the first in the county, and can be taken as a very low risk as can the single blast furnace site at Stanhope. Only limited evidence exists on site of the former works at Coxhoe, but reclamation has obviously not been fully comprehensive and new development has taken place nearby. Witton Park has the most visible dereliction, where the roughly levelled old heaps still dominate the area between the village and the River Wear. In terms of risk, in this preliminary assessment which adopts current policy criteria, none of the sites appear to be of great concern although Coxhoe could be made the subject of a more comprehensive desk study. Witton Park requires further consideration in view of the fact that a cokeworks was also present on the site.

17.1.3 Vein Minerals

The third type of working to be assessed is that relating to the vein minerals.

(a) Lead. This was examined initially in a typical area at Coldberry in Teesdale. The view has been taken in the past, and it remains reasonable, that visually these old lead workings do not constitute a problem, having been absorbed into the landscape and indeed adding something of interest in terms of industrial archaeology. Within this area the main smelting appears to have taken place at Blackton Beck, which could conceivably give rise to pollution problems, and on site there are extensive remains in the form of earthworks and disturbed ground where the location of the dams, water races and flue can still be traced (Beadle, 1980). Hazards in these circumstances are however not easily apparent and more investigation would be required to fully evaluate any risk. Within the designated block, 16 of the 32 sites identified from an analysis of mine records, appeared to justify further consideration, from a physical safety point of view. In addition, 12 of a set of 18 mines or groups of shafts shown on O.S. maps, but not on mine records, were similarly situated. The shafts and levels fall into four different categories, and examples of each were chosen for examination on site to refine the risk assessment in each case (Table 11.1). Of those sites from the mine records, which were also shown on O.S. maps, three mines were chosen for further examination. One mine (23) was on a footpath categorised as the fourth highest of five classifications. On site the level was found to be small and running water, giving the appearance of a drainage culvert. The two remaining sites were visible, one (10) on the side of a little used footpath and covered by farm rubbish, the other (31) near a footpath in a well frequented wooded area but not easily accessible and again giving the impression of merely a drainage outlet. In no cases was there any visible sign of the mine water being polluted. The second category is that where tips are shown on O.S. sheets but with no shaft or level. On site however, although two sites (13 and 14) were only visible as heaps, three levels were accessible. Two levels are adjacent to low category footpaths, with one (22) having a grid to stop entry whilst allowing drainage, and the other, (9) which appears to be a slight misplot, being sealed with masonry. The site selected on a medium category footpath (24) has a level with an open mouth entrance and clean mine drainage issuing. One mine was examined (18) where a level is quoted in mine records but nothing is shown on O.S. sheets other than sink holes in the vicinity. Although there is evidence of ground disturbance on site, no clear entrance can be seen in what appears as a large mound on the verge of a minor road. The last category is that of levels or shafts shown on the O.S. sheets but not identified in mine records. Two sites were looked at (NY9245-2778, NY9583-2963), in both cases being close to footpaths. Circumstances differed on site with the former shaft only visible as a depression in a field whilst the latter site had an open shaft only loosely protected by a metal sheet (Figure 17.6).

Figure 17.6 Lead Shaft

(b) Barite. Of the other vein minerals have been recovered, only barite working seems to have left conditions which could give rise to concern. The two major complexes at Lunehead and Closehouse on the western boundary of County Durham do not have public access which could necessitate assessment of risk from dereliction. Lunehead is remote, with only one 'B' class road passing the site and no public footpaths, whilst Closehead is a secure and still active mine. Visual, stability and stock grazing considerations at Lunehead do not give rise to any need for action, and Closehouse is regulated by the Mines and Quarries Act. Only at Cowgreen is there an interface with possible "receptors" due to the sites location in an area of great natural beauty with access to the Pennine Way long distance route, Cauldron Snout waterfall and the unique landscape with its alpine flora dependent on the granular "sugar" limestone (Trueman, 1949). The County Council has constructed a car park and facilities providing a focal point for walkers and others directly in the centre of the old mine workings. The veins which have been subject to mining come into conflict with widely used routes on a number of occasions. Most of the footpaths are categorised, in the system agreed with the Local Authority, as grade five, well used, with the exception being the route to the north west which is grade four. The Dubbysike group here has only a reopened lead mine which could be worth further examination. On the access road to the boathouse the Winterhush Vein workings appear to have left five shafts in close proximity to the road which are in a line clearly marked by collapses and sink holes, the consequences of which can also be seen in repairs to the road. Similarly to the north of the entrance road from the east, the line of the Holmes Vein is visible as a long depression with collapses and shake holes. To the north of the car park, in an area not served by official footpaths, but accessible from the parking places, the collapsed main drift on the Greenhush Vein is visible and further north are recently fenced off subsidence holes (Figure 17.7).

Figure 17.7 Barite Mine - Collapse

To the south of the main access, on the road to the dam, which is used also a footpath, a line of five shafts on the Rods Vein lies close to the road.

(c) Fluorite, Witherite, Sphalerite. These other vein minerals worked in the county do not appear to justify extensive separate examination. Although worked since 1882, fluorite has largely been won in association with lead (Smith, 1977) until more recent times when recovery came under planning law which provides the means to control any remedial work required. The mineral in itself is none polluting and does not justify separate risk assessment. Similarly, witherite has generally been won in conjunction with coal and at the one location where a specific shaft was sunk, the site has subsequently been opencasted. Zinc has only been occasionally explored as the reserves are limited and the impact of the prospecting equally insignificant.

17.1.4 Cokeworks.

These sites are potentially heavy polluters and require close examination, perhaps even where surface reclamation may have been carried out. The review of coke making plants in the county produced a list of 18, other than ancient beehive ovens which fall into a different category of risk. Of these 18, two thirds had been reclaimed, including the major sites at Consett, with Templetown, Randolph and Fishburn. Four of the works, at Langley Park, Bear Park, Shotton and Horden, which had closed after 1951 were not reclaimed until after publication of government guidelines on potential pollution from gasworks and should therefore be safe. Four works, however, at Stella Gill, Trimdon Grange, Tudhoe and Thrislington were restored before the dangers of by-products residues were widely known. Two recent major sites remain derelict at Hawthorn and at Lambton, where the site straddles the county boundary. Four additional works at Brancepeth, New Brancepeth, Stanhope and Malton have very different situations. Brancepeth works still exists on it's original site in a more limited form but related to the previous processes, whereas New Brancepeth remains are in a mature coniferous woodland where evidence of coal related activity is still visible. Little is known of the site at Stanhope which may have been connected with the blast furnace. At Malton, although again no details are available, a works has been identified and evidence of pollution appears to be present in the form of oil and tar wastes emanating from the site. Other industrial uses have taken place here however since the time of coke production and these may also have been responsible. Records suggest that two further collieries, at East Hetton and Roddymoor, although not shown on published plans of cokeworks in the county, also had ovens and, in the latter case, by-products recovery.

17.2 Initial observations

17.2.1 Coal.

In respect of coal, two typical areas were investigated, representing varied characteristics in different parts of the coalfield, but in neither case was there any significant omission in the reclamation carried out. Potential problems were mainly reduced to those related to shafts and drifts, as visual and stability considerations had generally been effectively dealt with. In the first area, of 37 sites examined, one shaft could have been a cause for concern but this had already been identified and appropriate action taken. Two sites were thought to justify some remedial treatment in respect of their visual impact. (Appendix 3). In the second case, none of the 28 sites appeared to pose a significant danger although it was clear from the circumstances at two locations that past filling of shafts cannot be a guarantee of permanent safety. It is not surprising, taking into account the priority given to reclamation of collieries, that no significant risks seem to remain. Past performance can therefore be said to be effective and there is no apparent need for further action. The only slight question mark may relate to those old mines, possibly predating modern and well surveyed records, where shafts or drifts, or shallow workings, are in close proximity to property. In these cases, either development has dealt with the problem or a risk may remain, the treatment of which will have to be agreed following changes in responsibility as a result of the privatisation of the Coal Industry.

17.2.2. Iron

Iron extraction took place in well defined areas which were also quite remote and, as with coal, visual impact and stability risks are not a major consideration. Of 73 features identified, only 16 were judged to pose possible problems and seven of these, situated in the Rookhope area, were examined on site. Of the five which were accessible, none presented a significant risk in terms of current policy, but some risk does exist in the form of acid mine drainage issuing from a drift, and the presence of a former lead mining pumping shaft within the vicinity. Iron works were limited in number in the county, and of these, eight could be excluded as significant risk in view of their status as either reclaimed sites, small and ancient locations or principally cold metal processing plants. One further site appears to have been largely reclaimed, although remnants exist in the area, and only the site at Witton Park, especially in view of its associated coke works, could be considered a significant risk potential.

17.2.3 Vein Minerals

The extensive vein minerals workings were dominated by the extraction of lead which affected large areas of Teesdale, Weardale and the north west of the county. Within the area selected for detailed examination, 16 of the 32 sites possibly at risk were assessed from the desk study as justifying closer examination. In addition, 18 unrecorded mines or groups of mines shown on O.S. maps were similarly considered to be potential problems. It is a characteristic of mine entrances that the great majority, in fact 26 of the 32 sites in the chosen area, are levels, as this appeared to be the preferred method of gaining access. Given the predominant place of the Great Limestone as a host rock for the mineral, and the convenience of outcrops along the valley sides it is not surprising that levels were the most economical means of working. It is also clear from the 11 inspections made on site that these drifts do not in general pose problems even in cases where they are in close proximity to well used rights of way. They are in the main visible and their small size, together with the mine water issuing, gives the impression of drainage culverts which would cause little concern. It is conceivable however that some exist in situations where entry would be unwise and in these cases, if no protective grill has been installed, it would be wise to do so. The relative distribution of shafts and levels is very different in the case of additional features shown on O.S. sheets, some of which may be only loosely referred to in mining records and others not at all. In the main these appear to be shafts and the two areas examined on site, both of which were close to low usage paths, suggest that only limited attention has been paid to their safety, with some having only loose metal covers over a void. Only one major smelting site was thought to exist in this area and, although no evidence of pollution has been commented upon or observed, it must be a possibility that contamination is present to a greater or lesser degree, given the nature of the heavy metal involved.

Barite mining in the vicinity of Cow Green appears to have left a legacy of old features which must represent an element of risk to the relatively large numbers of visitors attracted to this location. Collapses have clearly taken place, in some cases recently, and an analysis of risk in this area should be carried out.

Remains from the working of the other vein minerals of fluorite, witherite and zinc have also been examined and little risk is presented from any of these.

17.2.4 Cokeworks

These present potentially the most severe threat to the environment of any of the processes related to mineral extraction and, excluding beehive ovens which constitute a far lower level of risk, there were 18 in the county identified in records of the coal and iron industries. Of these, two major sites are unreclaimed and must inevitably be the subject of a proper risk assessment. Four have been recently reclaimed and a low level of risk should therefore be attached to these sites, provided the guidelines relating to gasworks sites have been followed. Four more have been reclaimed some years ago, but subsequent to the release of the guidelines, whereas a further four were reclaimed prior to the risk posed by these works being fully understood. Some concern must therefore exist, to a limited degree in some cases and more in others, that pollution pathways may remain which could be activated by changing circumstances. Four final sites were both smaller and older but again could give rise to difficulties if external influences modify the present conditions which appear for the time being to be in equilibrium.

18.0 POLICY REVIEW

18.1 Factors

When risk assessment is undertaken under the guidelines recommended by present government policy, very little reclamation of derelict land appears to be necessary in the county, despite the relatively narrow parameters which originally defined the programme which has been carried out and the extensive areas untouched by reclamation works. It may be prudent therefore to review the policy in the light of other considerations which have not so far been discussed, or have only been touched on. The risk assessments described earlier in Chapter 16 are guided by the consideration of factors set out in background research carried out for the Department of the Environment (CIRIA, 1995). This suggests requirements which should be met before further site investigation or a specific risk assessment are considered necessary, following which guidance is given on refinement of hazard assessment. The next steps then lead on to a system for determining priorities which can be given scores, as previously described. Some of the factors which can influence the decision on further action include:

* Doubts over generic values
* Frequency and dose of exposure
* Sensitivity of sites
* Actual or imminent threat
* Liabilities on operating sites

When the hazard assessment is undertaken, the possible receptor routes must be examined, as stated earlier, and in addition these should be qualified in the context of the factors listed above. In the case of groundwater pollution, for example, consideration must be given to the distribution of contamination, its solubility, the permeability of the ground, the direction and flow of groundwater, and likely exposure. Similar analysis can be carried out for other pathways and a qualitative or quantitative evaluation can then be done, all of which tends to emphasise the approach requiring proof of significant risk. At this stage however, more contributory influences are referred to, including the possibility of climatic change, flood risk, the impact of new construction and changes in the actual exposure of the hazard. The need to allow for uncertainty is stressed and the acceptability of risk, which balances the approach more towards a more proactive policy. Finally the costs and benefits of actions must be estimated before allocating priorities. If the situation in County Durham is reviewed, taking into account the guidance above, there are both general and specific conditions which will influence decisions on future action.

18.2. Standards

Generic standards used in the ICRCL publications are limited in their extent and, although intended as guidelines, are often used as fixed parameters without taking account of possible synergistic effects or allowing reasonable flexibility. They are used in conjunction with the policy of "suitable for use" which, unless allied to proper risk assessment, will not make adequate provision for off-site effects. Planning Policy Guidance Paper No.23 "Planning and Pollution Control" (DoE, 1994) gives advice on this but also appears to limit planning responsibility by stressing the need to avoid duplication of planning and pollution control functions. Other countries, notably the Netherlands, Germany and the U.S.A. have adopted a more rigorous multi-functionality approach. This may be driven by considerations such as protection of water abstraction, and reaction to major polluting incidents, but the nett result is the imposition of higher standards which result in a greater degree of protection for the environment in general. The latest guidelines from the Netherlands, which were the most stringent, do now however refine the risk and involve an "uncertainty" factor which may result in clean up not producing a pristine site. Most European countries which have a contaminated land policy, and not all do, carry out risk assessments in conjunction with site inspections and then place the sites in a grade of risk. Standards and procedures are under continual review through such European co-operation groups as NICOLE - A Network for Industrially Contaminated Land in Europe, and CARACAS - Concerted Action on Risk Assessment for Contaminated Land in the European Union, which it is hoped will lead to common approaches and standards. Although similarities in different policies exist, as in the way in which contamination potential is addressed through agreement on polluting industries, differences are also present as in "suitability for use", and approaches to liability. Great Britain is the only E.C. country, of those with a contaminated land policy, which does not have an appropriate register, although this may shortly come into being. Other differences arise in the attitude to "orphan" sites, where the polluter cannot be traced and the current owner cannot be held responsible, which is often the main consideration in determining whether or not effective clean up is possible. Evidence from the United States of the high proportion of "Superfund" resources spent on legal rather than works costs have almost certainly influenced here both the "polluter pays" concept and the stringent emphasis on the need for significant contamination to be present before action is justified. The levels of clean up action values, the attitude to uncertainty of receptor pathways and the imposition of liability on the polluter will all influence priorities for action on sites such as old cokeworks, resulting currently in low risk assessments on most sites in the county.

18.3. Metalliferous Mining

There are particular factors relating to conditions in County Durham which are not necessarily applicable to other areas, although one concerns metalliferous mining which is the subject of guidance from ICRCL. Only certain areas of the country have been affected in this way and particular attention has therefore to be paid to this situation. The former National Rivers Authority, now absorbed into the Environment Agency, expressed concern (NRA,1995) that *"old lead areas may erode, causing pollution downstream, and whilst this can lead to specific vegetation types growing on these areas, if mammals ingest silt with a high lead content the results can be fatal".* Departmental guidance (ICRCL, 1990) provides notes on interpretation of the threshold and action trigger levels for lead and other heavy metals, where these are present in areas used for grazing. The point is made that the concentrations quoted are for contamination derived from mine spoil, and for less favourable conditions lower trigger values would be appropriate. In situations where lead has been smelted, the hazard is more akin to that of old cokeworks where the contamination may be widespread and mobile, requiring more detailed examination to assess the risk. Research commissioned by the Department of the Environment (Richards, Moorehead and Laing, 1994) accepts that in some cases these sites continue to pollute the wider environment. Only the Killhope lead mining museum was included in the case studies in County Durham, and it was assumed that this had been fully reclaimed.

18.4 Coal Industry Act

With regard to coal, the Coal Industry Act,1994 may affect responsibility in respect of both restoration of pre-1948 abandoned mines and the impact of acid mine drainage. Problems in older mines, and changes in groundwater brought about by alteration of pumping regimes, are two areas where action may be necessary. Under the Act, it is now possible to impose, with compensation, restoration conditions on mines closed before 1948 which were previously not covered by the provisions of the Minerals Act, 1981. In addition, exemptions given for discharges of mine water will cease in 1999 for mines remaining at that time. The legal implications of this are not clear but it is arguable that cessation of pumping in an abandoned mine is a cause in a chain of operations, and a potential offence under the Water Resources Act, 1991. The impact of old abandoned mines may therefore justify further examination.

18.5 Access

The final consideration is that of access, affecting old mineral workings, and the responsibility of landowners. The potential problems arising from the mining of lead, barite and other vein minerals arise over a wide area, much of which is formerly unspoilt open country and still has a great attraction for visitors. Ownership of the shafts and drifts, in contrast to the situation with coal, rests with the original person who constructed the entrance, the owner of the mineral rights or the current landowner. Legally under the Mines and Quarries Act, 1954, there is no obligation to make safe shafts which have not been worked since 1872 and this includes many of, but not all, the former lead mines. Barite has certainly been worked until recent times. Action could still be taken under the statutory nuisance provision of the Public Health Act, 1936 where an unprotected mine "by reason of it's accessibility from a highway or place of public resort constitutes a danger to members of the public". The responsibility of the landowner and the probability of receptors coming into contact with the hazard are therefore critical factors. In the absence of general legal rights to walk on open ground, access is officially limited to rights of way and local authorities in other vein mineral mining areas have adopted a policy of sealing shafts within 100 metres of footpaths or bridleways and asking walkers to notify them of any open shafts which are found. This is a cautious approach and there are instances of case law which may be relevant in protecting the position of the landowner or local authority. The first Court of Appeal decision, in the case of Cotton v Derbyshire Dales District Council, found that where dangers are obvious in themselves, the landowner is under no obligation to provide warnings. In the second case of McGeown v The Northern Ireland Housing Executive, which was taken to the House of Lords, it was found that there is no duty to maintain rights of way on open land in good condition. Old legislation, especially where questioned by recent case law, may therefore be difficult to implement and actual progress is more likely to be achieved by co-operation and offers of limited assistance.

19.0 CONCLUSIONS AND RECOMMENDATIONS

19.1 Risk Present

19.1.1 Coal

The coal industry has been the main object of a long and sustained reclamation programme, both nationally and locally, and this has resulted in the transformation of the landscape and environmental conditions in County Durham. It is readily apparent that visually the problems of coal mining and processing have virtually disappeared, and the sample areas inspected produced only two relatively small sites where some work could be considered to be justified on these grounds alone. Extrapolation across the whole coalfield would be unlikely to generate many other similar sites and problems of instability are also considered to have been addressed. The possible risks which may remain are related to underground works in the form of shafts, drifts, shallow workings and acid mine drainage. Only one old shaft in the two areas inspected proved to have a significant risk but doubts remain concerning other, apparently unreclaimed, shafts in urban areas together with possible risks from shallow workings and mine drainage. The screening system used in this investigation has proved effective in identifying some possible areas where risk could exist but it may not be the best or only option. Screening by name and only subsequently taking account of opencasting is clearly inefficient, given the extent of these works in the county and the fact that they deal comprehensively with dereliction and old areas of coal extraction. Equally it appears unlikely that benefit would be gained from a general examination of old mines in rural areas, as there is little evidence of problems to date and the impact of any collapse or severe settlement would be limited. Concentration in these situations on areas where past mining coincides with popular access routes or any locations producing gatherings of people would be more effective. The attempts to find an easy method for identifying potential problems related to the coal industry, which could be applied in urban areas, suffer from failings caused by deficiencies in either the mine records used or reliance on old O.S. maps, which do not in any event provide a complete coverage. It has been observed in the corrections made manually to the N.C.B. records used in these searches, by mining surveyors dealing with specific areas in detail, that inaccuracies exist. As has been stated earlier, the use of generic names for mine complexes covering a wide area, and local usage of different or alternative names complicates the issue and produces uncertainty. It is also clear from research by Symons (Healy, 1984) that old O.S. maps cannot be relied upon totally to identify redundant shafts. There does not therefore appear to be any alternative, where disused shafts or shallow workings are suspected, to investigation by means of the detailed mine records available. It is only in the identification of potential areas of risk that savings can be made and systems now exist to assist this process. Acid mine drainage is a separate, particular problem which may occur in County Durham, depending on actions taken in connection with the pumping of closed, deep mines. Investigations being undertaken should determine the most appropriate methods of dealing with this potential hazard.

19.1.2 Vein Minerals

The locations of vein mineral workings are mainly well defined by linear features which it is possible to trace on the surface. The only exception is where iron "flats" have been worked by opencasting but these sites present no major problems. Little reclamation work has been seen as justified as the workings are largely in rural areas and not visually unattractive. Public access is possible however leading to occasions where potential risks are apparent, as can be seen in the sample areas examined, and the degree to which this may be a problem depends upon public use. It is clear from the limited exercise carried out to classify usage of rights of way, in the trial areas for lead, iron and barite, that it would be possible to highlight those footpaths, bridleways and centres of attraction where public access is frequent. Risk assessment would thus become a reversal of normal practice, by first defining the receptor and then utilising mining records to identify possible hazards with which they could become associated. It is suggested that this would be a more effective way of proceeding than attempting to carry out a risk assessment on the many potential hazards spread over the widespread mining areas. This exercise need not include mining or processing of zinc, witherite or fluorite which do not appear to cause concern.

19.1.3 Cokeworks and Smelting

The sites in the county most likely to constitute a contamination hazard are those related to either cokeworks or metal smelting. Iron works are not seen as a serious risk in themselves, but only where an associated cokeworks existed, and only a limited number of sites were used for lead smelting. Cokeworks were quite numerous however and whilst some will have been reclaimed effectively, others give rise to doubt as a result of timing and the state of knowledge then existing. Given the potential risks from these types of works, it would be prudent to carry out desk studies of known cokeworks and smelting sites to establish possible receptors, following which further steps may be required in the way of site investigation. A number of sites, including one as yet unreclaimed, appear to have pathways to significant watercourses.

19.1.4 Quarries and Claypits

Quarries and claypits present different problems, but both are apparently low risk. Only where the increasing importance of tourism could be a cause for reassessment would it be possible to justify works on quarries, perhaps in the form of controlled blasting as described earlier (Figure 19.1).

Figure 19.1 Quarry - Teesdale

Pits from brick clay extraction are only likely to become a risk in respect of methane production and few sites appear to be related to the waste disposal which could cause this to occur. Waste Regulation Authorities had anticipated that requirements for contaminated land registers, in the Environmental Protection Act 1990, would ensure that all suspect sites would be checked by Local Authorities. The abandonment of these proposals, however, means that no systematic survey of older sites has been carried out. The Environment Agency is producing zonal maps for groundwater protection which will also provide a useful check.

19.2 Conclusions

Examination of areas of mineral extraction and processing has demonstrated that, although the derelict land reclamation programme carried out to date in County Durham has been very successful, especially in respect of visual and stability considerations, some areas of concern remain. The potential risk considered to be present varies from one mineral to another, as does the approach which may be required to verify the degree of risk and the recommendations for further action.

Recommendations in publications sponsored by the Department of the Environment and elsewhere (CIRIA, 1995) are that sites should be prioritised in the form:-

Category One -	Immediate action
Category Two -	Urgent investigation
Category Three -	Investigate in due course
Category Four -	No risk

The overall conclusion of the effectiveness of the reclamation programme in County Durham, when assessed against the background of the original causes of the dereliction, is that only a small number of sites fall into Category two, requiring urgent investigation. More could be put in Category three, to be investigated in due course, whilst most of the unreclaimed areas would be Category four, considered to be no risk. Coal mining may only have residual problems where old mines in urban areas have not been fully reclaimed. Vein minerals should be examined in the context of public access, whilst potentially contaminated sites such as cokeworks and smelting sites justify a precautionary desk study. Potential problems at Waste Disposal Sites have not been fully evaluated and this is an exercise which should be carried out.

19.3 Recommendations

Although discounted until now as a practicable method, the application of a Geographic Information System (GIS) to the assessment of derelict land is becoming more realistic and could provide the means to search for risk areas in a cost effective manner. The generally widespread availability and power of computing facilities will increasingly allow access to relevant digital data stored in this way. Accurate plotting onto an Ordnance Survey map of derelict land records, at a larger scale than is used at present, together with opencast records, could form a base which would reduce substantially the search areas. To this could be added mine data, filled in pits and other information which is already held nationally by commercial organisations, but can also be obtained in other ways. Risk zones designated by urban boundaries, other selected properties, well used rights of way and proximity to controlled waters, would then limit the extent of those areas where desk studies may suggest further investigation is required before possibly a full risk assessment.

20.0 EXECUTIVE SUMMARY

The purpose of this study has been to address the question as to whether or not the programme of derelict land reclamation carried out in County Durham has dealt adequately with the overall problem or has, by concentrating on visual and economic considerations, left a legacy of unsafe sites, still requiring attention. The priority for treatment within the county has been largely dictated by considerations of visual impact and location whereas the origins of derelict land are widespread and associated with both the geology of the county and the related earlier patterns of industry.

I therefore began by examining the main mineral extractions which had taken place, in each case reviewing the geological structure which had resulted in the particular distribution of the mineral. This in turn dictated the working pattern of the related industry.

County Durham has, to a large extent, been dominated by coal and the way in which this was deposited has influenced both the timing and methods of working, resulting in different patterns of dereliction across the coalfield. The general dip to the east, and erosion prior to deposition of the Permian strata, below which the coal measures are concealed in the east, has influenced the nature and value of individual seams. I have stressed the importance of the geothermal gradient above the Alston Block which, together with a similar effect caused by the heat associated with intrusive dykes, has resulted in alteration of coal rank. The significance of this lies in the suitability of the coal type for use in coking plants which I have explained in succeeding chapters. Investigation of the history of mining and the way in which this related to the geology of the area has then been used to set the background against which I have analysed available records of previous workings and related reclamation. It appeared from the National Coal Board records that screening of areas of working defined by unique grid square references, against actual reclamation sites, could provide the means of determining areas where problems might still exist. I have explained the way in which the NCB records were compared with local authority reclamation records, concentrating on two typical areas, one in the west and one in the east. This resulted in substantial numbers of apparently derelict sites, the locations of which were then more closely defined through searches of old Ordnance Survey maps. The difficulties of using local mine names has been explained together with reservations about the completeness of O.S. maps as a definitive record. It also became clear that the incidence of opencasting has had a substantial influence on the existence or otherwise of remaining dereliction and I have explained the impact of this in the respective areas of the coalfield. To complete the review of coal I examined the nature of the problems which can occur when mining has been carried out, including both physical and chemical/biological effects. These vary depending on the type of mining and include tip instability, the presence of shafts and drifts, gas generation, leachate and collapses of shallow workings.

The second mineral examined was iron, which was formed in County Durham in two different ways, as sedimentary ores or as a vein intrusion. The sedimentary ores were limited in extent and had little impact, being mainly associated with already functioning coal mines. The vein minerals, by contrast, resulted in defined areas of working in the dales, unrelated to the coalfield. I looked initially at the overall distribution of these ores, and their relationship to the Alston Block and, by examination of mining records and literature, identified the main areas of interest which follow a well defined pattern. In the succeeding chapter I looked more closely at iron mine records and produced a complete schedule of old workings which was used to determine those sites where problems could be thought to remain. As a result of this, I selected the area of the Red Vein, in the Rookhope valley, for more detailed examination as it contained many formerly productive sites in a concentrated zone. The processing of iron ore and the production of iron and steel can have significant consequences and I therefore reviewed the history of different processes used and the way in which they were utilised in

County Durham. This emphasised the way in which the exhaustion of ores, the development of other major resources in the country and the relationship of iron production to Durham coking coals influenced the distribution of the iron and steel works in the county. As a result of this I was able to produce a schedule of works which could have resulted in dereliction and contamination, and their current status. Finally, as with coal, I reviewed the problems which could arise from the processes of iron mining and smelting.

The next minerals to be examined were in a group including lead, sphalerite, fluorite, barite and witherite. It was again necessary to begin by defining the areas in which deposition of these ores occurred and how the geology of the area, especially the Alston Block, influenced this. I have explained the zoning of different minerals and how this limits the extent of each type of working, making analysis of possible dereliction more systematic and less complex than would otherwise be the case. It became clear to me from an examination of the history of lead working that the long duration of this activity and the widespread distribution of sites had resulted in many affected areas, very few of which had been the subject of reclamation. Full analysis of the huge number of potential problems was therefore judged to be impractical on a county wide basis, and a sample area of some 20sq.km, which had been extensively worked, was selected for closer examination. The intention of this was to assess the feasibility of reducing the total number by a process of general screening before inspecting the remainder on a site by site basis. Fluorite, by contrast, was only won from a limited number of locations, all of which were inspected to assess the extent of works and their current condition. Sphalerite was only deposited in localized zones and the works were found to be small in scale, not requiring detailed analysis. Barite however, although only recovered from a limited number of sites, was extensively mined and the main extraction areas at Lunedale/Closehouse and Cowgreen were inspected, resulting in a decision to further examine Cowgreen where abandoned workings were considered more likely to have left problems. I also looked at the distribution of the other barium ore, witherite, which was found to be of only limited relevance, being mainly associated with coal and extracted concurrently from deep mines. Having assessed the general distribution of all the vein minerals I examined each in turn more closely to determine the actual features associated with each mine, identifying not only those contained in records but also evidence on old maps of the working zones. The nature of the problems which could be anticipated was then examined, taking into account the physical risks, which are similar to those from other mines, but compounded by the particular risks associated with the toxicity of lead.

Although coal was considered initially in overall terms, I considered it necessary to deal specifically with the specialized case of coking coal, given the particular contamination problems caused by the production process. A review of the historical development of the process was carried out, differentiating between early "beehive" ovens and later, more sophisticated, methods involving by-product recovery. As a result of this, and published information on the coking industry, I was able to compile a schedule of the sites which would be likely to have left residual contamination. This related well to the distribution of coal rank and other factors such as transport links to other iron and steel works to the south. As with other minerals, the potential hazards of former cokeworks were assessed to allow evaluation of the inherent risk in these sites.

Finally, although not thought to be a serious concern, the surface extraction of brick clay, rock and aggregates was briefly examined together with different methods of restoration. An important element of this was the impact of waste disposal where this has been a side effect of the creation of voids from mineral extraction.

Having looked at the origins, history, problems and distribution of potentially difficult sites, the next step was to assess the risk from these in order to determine whether or not treatment could be justified. I therefore addressed first the nature of risk, before examining the approach adopted by the United Kingdom government in respect of derelict and contaminated land. Having reviewed interpretations of this by other bodies it was possible to form a preliminary view on an appropriate response to untreated sites and this was done for each mineral in respect of those suspect sites identified in earlier chapters. Each identified site was assessed in terms of potential risk by means of a desk study taking into account the sites type and accessibility. I also examined a representative sample of sites on the ground to verify the actual conditions. In only a limited number of cases could there be said to be any justification for treatment when applying current guidelines. Having reached these initial conclusions it seemed prudent to review current policy in the light of other considerations expressed in background research reading. Factors which can influence decisions on further action are identified in advice notes prepared by the government, international requirements and case law. Specifically, differences of view over generic pollution standards used in the United Kingdom, particular conditions applying to metalliferous mining sites, the impact of the Coal Industry Act and practical considerations of access, all mitigate or enhance the need for further action. I therefore re-examined the sites against the background of a more cautious approach to the risks involved, considering the effectiveness of past work and the possible case for wider investigation or treatment. This required at the same time a judgement on the dependability of the methods used in this study to establish a practical working approach.

I concluded that, in respect of coal, the system of screening sites from the N.C.B. abandoned mine register was not wholly reliable and emphasis should still be placed on full examination of old mine records with particular attention being paid to urban areas. Vein mineral works are so widespread, and predominantly rural, that it is unnecessary and impractical to evaluate all possible sites. I have proposed that definitions of risk areas using criteria of access and general type of working would be the most effective way of reducing the workload required to assess risk in this category. In the case of cokeworks and smelting sites, the potential risks can be so serious that a desk study of the limited number of sites involved would be a justifiable precaution.

My final recommendation is that consideration could be given to the use of new computer based techniques, which are now available, to screen potential risk areas and thus reduce the suspect areas to manageable dimensions before closer examination. The justification for this depends on the likely level of hazard which does not, at present, appear to be significant in County Durham, and efforts should therefore be concentrated for the time being on the limited number of identified problems. Production of composite records however, including mineral and industrial working, reclamation to date and other relevant factors, such as access and opencasting, would be a logical next step, forming the base for digital map analysis should future demands, such as the Environmental Protection Act regulations, require this.

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APPENDIX 1

RECLAIMED SITES NOT ISSUED BY N.C.B.

Reclaimed site	Derelict Land Ref.	N.C.B.Map	N.C.B.Grid	N.C.B.Mine
12NE				
Hunters Hill	R35	41NE	G12	Etherley
12NW				
New Carterthorne	R256	41NE	DE/6	Tees West,Toft Hill
13NE				
Church Hill	R583	34NW	C2	Crook
Oakenshaw	R283	26SW	F9/10	Brancepeth (Opencast)
Tanners Hall	R42	26SW	G5	Bowden Close
Woodfield	R95	33NE	D11/12	Woodifield
13NW				
Cabin House	R416	33NE	C5	Cold Knott/Harperley Lane
13SE				
Brackenhill	R414	34SW	A5	Rough Lea, Hunwick
Escomb	R37	42NW	A6	Old Etherley
George Pit,Escomb	R643	34SW	H2/3	Etherley
14NE				
Fenhall Drift	R204	19NW	D1	Addendum-closed 1963
14NW				
Esp Green Drift	R485	11SE	H8	Pump/Exit-Delves Lane
14SE				
New Ivesley	R250	26NW	F3	Ivesley, Old Ivesley
15NW				
High Westwood	R381	11NW	A12	Westwood, Copelands
15SW				
Watling St.Leadgate	R142	11SE	B2/C2	Berry Edge
Willow Cr.Leadgate	R141	11SE	E3	Crookhall
22NW				
Princess Street	R150	42SE	B3	Shildon Lodge
South Shildon	R636	42SE	E5/6	Shildon, New Shildon
23 NW				
New Row	R284	26SW	G9/10	Brancepeth (Opencast)
Meadowfield	R27	26SE	B9/10C9/10	Browney, Littleburn
24SW				
Scout House	R51	26NE	C4	New Brancepeth
25NW				
Causey Mill	R311	12NW	B10/11	Beamish Park
35SW				
Lumley Burn	R436	13SE	F1	Lumley 6th.
43NW				
Hesledon Colliery	R687	28SE	E9/10F9/10	Castle Eden

APPENDIX 2

Colliery Names
Shildon - Sheet 42

Local Name	N.C.B. Grid Ref.	Reclamation Record	Grid match	N.C.B. Name
B" 1810 - 1830	NE - H4	Adelaide - R264	H4	Adelaide
D" 1810 - 1830	NE - A3	Adelaide - R264	H3	Adelaide Jane
Deanery 1810 - 1840	NE - G3	Adelaide - R264	G3	Deanery
Adelaide 1830 - 1924	NE - G2	Adelaide - R264	G2	Adelaide
Shildon Lodge(Datton) 1830 - 1924	SE - B3	Possible - R276 Land at West Street	B3	Shildon Lodge Entrance at D4
Coppycrook (Seymours)1835 - 1852	SW - A/B12			Coppycrooks
Dabbleduck 1866-1922	D6	Possible R244-Soho	D5	Shildon New
Furnace (Smokey) 1866 - 1923	SE - D3	Furnace - R151	D3	Shildon Lodge
West Durham (Wallsend) 1894-1924	SE - B1	Cemetery Heaps-N451 Justifying Reclamation		Durham Wallsend West
Coppycrook (Spoors) 1898 - 1950	SW - B11			Coppycrooks
South Church Drift 1933 - 1940	NE - G2	With Adelaide- R264	H3	South Church
Tunnel 1936 - 1948	SE - A4	Tunnel Top Heap-R21	A4	Tunnel
Princess Street Drifts 1939 - 1959	SE - B2	Princess Street Heap R150	B3	No.1 and No. 2
Deanery New Drift 1945 - 1948	SE - A4	With Tunnel	A4	Deanery

Mine	Sheet Ref.	NCB Ref.	Feature	Map. Ref.	Site Description	Comment
Abbots Close	N.E.	D5	Two shafts	1393 - 3526	On Public Footpath-fenced off-signs of collapse	Closed 1877-1928-1932
				1373 - 3530	Agricultural-not visible	
Bedburn/Bitchburn	N.E.	E6/F7	Two drifts	1407 - 3464	Agricultural-not visible	Wolsingham Parish-1924.
				1412 - 3472	Pit heap remains-works justified	
Coal Bank	N.E.	D5/6,E6	Four drifts	1362 - 3506	Agricultural-not visible-inaccessible	Closed 1939
				1390 - 3512		
				1396 - 3473		
				1397 - 3470		
			Trial shaft	1384 - 3508		
Collier Wood	N.E.	A3,A4	Drift	1297 - 3646	Wooded-A68 Picnic Area-not visible	Closed 1949
Crook	N.E.	B11	Shaft	1606 - 3602	In town-Public Open Space-not visible	
Friends Farm	N.E.	DEFG/12	Shaft	1630 - 3499	Grassed area adjacent to housing-not visible	Crook and Billy Row 1824. Closed 1
			Air shaft	1624 - 3490	Road and carpark in Industrial Estate-not visible	
			Shaft	1639 - 3446	Possibly reclaimed-not visible.Pit heap adjacent-works justified	
Greenhead Colliery	N.E.	F8,G8	Four drifts	1428 - 3462	Agricultural-not visible-inaccessible	Closed 1947. Durham Co.Co.-NJR
				1435 - 3460		
				1454 - 3438		
				1459 - 3442		
			Three shafts	1436 - 3462		
				1444 - 3452		
				1462 - 3446		
Harperley Park Colliery	N.E.	C3	Shaft	1285 - 3554	Wooded area-no access-location visible	Closed 1938
			Drift	1281 - 3556		
High Woodifield	N.E.	D8/9,E8	Two shafts	1422 - 3509	Agricultural-location mounded over	Closed 1926
				1434 - 3486	Agricultural-remote	
			Two drifts	1491 - 3491	Agricultural-visible hollows and mine workings-not accessible	
				1556 - 3477		
			Three airshafts	1481 - 3506		
				1490 - 3492		
				1540 - 3480		
Hollin Hall	N.E.	F5	Not shown		Derelict Industrial Area-no access	Abandoned 1949
Marshall Green	S.E.	D9	Two shafts	1519 - 3213	Wet hollow in field	Abandoned 1955
				1530 - 3194	Agricultural-not visible	
			Airshaft	1540 - 3188	Agricultural-stone tower marking site	
Wolsingham Parish	N.W.	FGH/2	Shaft	0725 - 3374	Moorland-remote	Wolsingham Parish-1924
			Drift	0725 - 3435		
Wood/Prince Edward	S.E.	A11/B11	Two shafts	1575 - 3306	Agricultural-not visible	Reclaimed with NandW Bitchburn-D
				1578 - 3300		

APPENDIX 3

O.S. Sheet 27 - Detail

Mine	Sheet Ref.	NCB Ref.	Feature	Map Ref.	Site Description	Comment
Cassop	S.E.	D8	Two shafts	3402-3841	Situated in National Nature Reserve-not visible	Closed 1839-78
				3404-3833		
			Air shaft	3181-3924	In opencast site	Remote shaft
Cassop Vale	S.E.	C6	Two shafts	3318-3900	Scrub woodland-mound visible	Fenced from adjacent footpaths
				3322-3908	Visible remains in wooded area	
Coxhoe					General area description	
Crowtrees	S.E.	G6			Reclaimed with Coxhoe Limekilns	Advice from Durham County Council
Croxdale Colliery	S.W.	H1	Shaft	2667-3700	Agriculture-not visible	Closed 1931-36
Elvet	N.W.	E4	Three shafts	2758-4157	At University Library-1 Capped and 3 built over	Abandoned 1908
				2758-4158		
				2762-4157		
			Air shaft	2759-4158		
Farewell Hall	S.W.	B2,C2	Two shafts	2675-3926	Agriculture-Mound visible	
				2675-3916		
Heugh Hall	S.E.		Air shaft	3166-3828	Agriculture-remote	Main site reclaimed
Hollow Drift	N.W.		Not shown	2832-4212	In works yard-nothing visible	Name only
Houghall	N.W.	G5,G6	Three shafts	2818-4057	Filled-with ring wall and cover	Abandoned 1872-86
				2818-4054		
				2817-4053		
Kepier	N.W.	A7,A8	Shaft	2894-4292	Local Authority Depot-concrete surface	Abandoned 1872
Old Durham	N.W.	D8,D9	Shaft	2921-4151	Depressions visible in field	Abandoned 1876-83
			Air shaft	2923-4159		
Quarrington Hill					General Area Description	
Riverside	N.W.		Shaft	2746-4175	Stone protective feature	Probably Elvet Colliery
Shincliffe	N.W.	H10		2997-3998	Grassed area in housing-not visible	Abandoned 1886
South Hetton	S.E.	H8	Drift	3378-3710	Reclaimed Public Open Space	Closed 1858
St.Oswalds	N.W.	F2	Shaft	2671-4092	On Golf Course-not visible	Parish records-1923
Whitwell Colliery	S.W.	B12	Shaft	3096-4058	Agriculture-mine remains and depression visible	Abandoned 1884-1923
Whitwell House	S.W.		Two shafts	3106-3998	Large mounded feature	
Whitwell House	S.W.			3103-4005		
Whitwell Low Grange	S.W.		Shaft	3035-3970	Depression visible in mature wood	

APPENDIX 4

Iron Ore Extraction — **APPENDIX 5**

	Vein	Mine	Date worked	Method of working	Extent	Tonnage	Location (NY/NZ)	Details	Geology (Vein)	O.S. Evidence	Location	Need for treatment
		Weardale										
1a	Red	West Groverake		Opencast	3-4ft./Vein + 500ft.	Extensive	891-436	Works in Lower Felltop LMS	Burtree Pasture vein/off Red Vein	Pit/Quarry	Remote	Unlikely
1b	Red			Deep mine	4.4-5.5ft./600x150ft.		8910-4361	From quarry		Level(Disused)	Remote	Unlikely
2a	Red	Rispey mine		Deep-shaft61m(200ft)	2ft./1684x24ft.	200t/wk-Ankerite	9109-4280	Main resource in area	From Little and Great LMS	Shaft(Disused)	Footpath 40m.	Check-possible
2b	Red			Two levels		30t/wk-Limonite		Lead as by-product	Rispey vein/off Red vein			Unlikely
3	Red	Scarsike vein	1851-1853	Level from surface		Not much ore	9131-4270	Ore remnants in heap	Remote site	Mineworks(Disused)	Remote	Unlikely
4	Red	Low Fulwood			800 x 400ft.		9340-4292	Re-opened lead mine	In Fulwood-Terminates at Red Vein	Shaft(Disused)	Footpath 50m.	Check-but lead mine
5a	Red	Boltsburn West		Level	4200 ft.	Substantial	9365-4283	Limonite 29.0-31.1%	Boltsburn/Red Vein junction		Footpath-near village	Check
5b	Red						9275-4217		Connects to Patersons/Fulwood	Mineworks(Disused)	On hill footpath	Unlikely
5c	Red			Level			9376-4272	Siderite 47.1%			Footpath-near village	Check
6	Red	North Grain		Opencast			883-449	In Felltop LMS		Quarry(Disused)	Near road	Unlikely
7a	Red	Frazer's Hushes		Opencast	3-5.5ft/1300ftx700ft	Extensive	881-445	In Felltop LMS		Quarry(Disused)	Remote	Unlikely
7b	Red			Deep	2ft./600x150ft.			From shaft with lead	Greencleugh - Ext. of Red Vein		Remote	Unlikely
8a	Red	Groverake	Mid 19th.Cent.	Opencast		Substantial	896-442		Main junction of Red/Groverake/	Quarry(Disused)	Hill footpath/road jct.	Unlikely
8b	Red			Wallaces Level			8989-4416		Greencleugh/Burtree Pasture	Quarry(Disused)	Hill footpath 20m.	Check
9a	Red	Mill Level		Level	Unsuccessful	Barren	9242-4302		Rispey-off Red Vein	Shaft(Disused)	Road 30m.	Check
9b	Red			Drift			9268-4323			Shaft(Disused)	Minor road	Check
10	Red	Stanhopeburn		Opencast(Noahs Ark)			981-408		Extension of Red Vein	Quarry/shaft(Disused)	Near footpath(Wood)	Unlikely
11	Red	Crawley	1847-1878	Level	3000 ft.	500,000t (Est.)	9884-4073	Iron only	Lanehead/Red Vein junction	Mine/shaft(Disused)	Footpath nr.Stanhope	Check
12	Remote	Boltsburn East		Level	Evidence of workings		957-446	Limonite with previous lead	Boltsburn	Quarry(Disused)	Remote	Unlikely
13	Remote	Hangingwalls Mine		No details	Evidence of workings		9417-4073	Worked with lead	Brandon Walls - Ext.of Heights N.	Shake holes	Footpath 20m.	Check - possible
14a	Remote	Brandon Walls Mine		Adit	Ore obtained		9476-4118	Mainly iron	As above-remote from Red/Slitt	Quarry(Disused)	Footpath 10m.	Check - possible
14b	Remote			Shaft			9487-4125	Winding shaft		Shaft	Road/footpath jct.	Check - possible
15a	Remote	Wager Burn		Opencast	Some ore obtained		NZ0024-3466		Separate vein system	Pit(Disused)	Near road(Wood)	Unlikely
15b	Remote			Opencast	Probably mined		NZ0060-3480		Indirect connection to Slitt		Road 100m.	Unlikely
16	Remote	Queensberry Workings	Mid-19th.Cent.	Opencast	700 ft. width		859-413			Shaft(Disused)	Footpath 120m.	Unlikely
17a	Remote	Snodberry	1906-1907	Opencast		Some ore		Flat in vein - worked iron only	West of Burtreeford disturbance			
17b	Remote		1940	Outcrop	60ft. wide		8294-4294	50.86% Limonite			Road	Check - possible
18a	Remote	Captains Cleugh		Level	6ft. vein + 20 ft.	No records	9497-4095		Brandon Walls vein		Footpath 80m.	Unlikely
18b	Remote			Shaft			9530-4106		Captain's Cleugh vein	Shaft	Footpath 280m.	Unlikely
19	Remote	Middlehope	1884-1889	Level	Some reworking		9044-4011	Old lead mine/30.7-38.2%ore	Richard's vein	Mine(Disused)	Footpath(dead end)	Unlikely
20	Remote	Hollywell			1740ft main/1225ft N		NZ0202-3733	Worked with lead			Road 40m.	Unlikely
21	Remote	East Dryburn		Level	36ft. Length 500ft.	Irregular	NZ0315-3693	Iron only			Urban footpath - 20m.	Check
22a	Slitt	Wearhead vein	1884-1888	Opencast	350x100 ft.		861-397	Iron content 31.3-38.1%	Slitt/Wearhead junction	Quarry/shafts(Disused)	Adjacent footpath	Unlikely
22b	Slitt		1929-1930	Level			8626-3982	27.6% - toolow	Trial only	Shake holes	On minor road	Check - housing
23	Slitt	Sunnyside		Opencast	Small ironstone flat		878-390	Limonite 44.3%	Scarsike New vein-related to Slitt	Mine(Disused)	Road 50m.	Unlikely
24	Slitt	Heights	1860-1863	Levels	7-8ft.	141,491tons	921-392	Some lead but mainly iron	Heights North- close to Slitt	Level(Disused)	Road 320m.	Unlikely
25a	Slitt	West Slitt	Ancient	Level	2000 - 3000 ft.		9015-3923	Iron only	Main Slitt vein	Workings	Track/footpath 50m.	Check
25b	Slitt			2nd. Level			9023-3950				Track/footpath 150m.	Check
26a	Slitt	Slitt Pasture		Opencast	Surface evidence		910-392	Principle source in late 19th.	Main Slitt vein	Mine(Disused)	Adjacent road	Unlikely
26b	Slitt	West Rigg		Opencast	150-200 ft.		911-392	century/34-43%iron		Mine(Disused)	Adjacent road	Unlikely
26c	Slitt	Rigg Mine		Opencast			915-390			Mine(Disused)	Adjacent road	Unlikely
26d	Slitt	Sider's Level		Level			9169-3866	Blocked at shaft/9167-3878	For iron at lower levels	Level(Disused)	Footpath 100m.	Unlikely
27a	Slitt	Allergill		Opencast			9710-3760	Only 17.7% ore	Allergill with Slitt(indistinct)		On footpath	Unlikely
27b	Slitt			Shallow opencast			9645-3673				Footpath 150m.	Unlikely
28	Slitt	Sidehead	1942	Not apparently worked	12-14 ft. 125 ft. long		8895-3875	45% iron	Possibly relates to Rowantree	Quarries(Disused)	Footpath 50m.	Unlikely
29	Slitt	Shield's Close			Apparently worked	No records	9088-3965	By Iron Company	Shield's Close - close to Slitt		Track 170m.	Unlikely
30	Swinhope	Carricks Low vein		Opencast			857-376			Mine(Disused)	Bridleway 100m.	Unlikely
31a	Swinhope	1. High		Entrance			861-380		Many cross veins on Swinhope	Mine(Disused)	On bridleway	Check
31b	Swinhope	2. Lowes										
31c	Swinhope	3. Dawsons	1888-1919	Surface hushes and	Bottom 10-20ft.	342,703t		Important for iron ore		Shake holes/Mines/	Remote-no rights of way	Unlikely
31d	Swinhope	4. Maddisons	1940-1946	shallow shafts	Vein + 200 ft.	1000t/wk.max		First worked with lead		Veins/shafts(Disused)		
31e	Swinhope	5. Far						33.46-60.36% Limonite				
31f	Swinhope	6. Nos. 4 and 5				Total >500t						
32	Swinhope	Rowantree		Levels			870-374	Iron only	Cross veins adjacent Swinhope	Mine(Disused)	Track - no right of way	Unlikely
		Teesdale										
T1a	T-Bands	Bands Vein		Level	30ft. wide		8294-3315	Poor/ 21.8-33.0% iron.High		Tip (Disused)	Road 60m.	Unlikely
T1b	T-Bands			Dump			8300-3320	silica. W of Burtreeford		Levels(Disused)	Road 120m.	Unlikely
T2a	T-Moss	Langdon Beck		Adits			8463-3485	Limonite 20.5-62.9%		Levels(Disused)	Remote - fell road	Unlikely
T2b	T-Moss						8464-3487			Levels(Disused)	Remote - fell road	Unlikely
T2c	T-Moss			Level			8504-3355			Enclosures	Remote - fell road	Unlikely
T2d	T-Moss			Shaft			8559-3382				Remote - fell road	Unlikely
T3	T-F'mere	Flushiemere		Level	40ft. wide		9095-3104	Limonite 63.5%	Extension of Swinhope in W'dale	Enclosure	Track - no right of way	Unlikely
T4a	T-Minor	Ettersgill		Outcrop			8904-2909	48.8%Siderite.Not possible	Minor cross veins off Teesdale	Enclosure(Dirt Pitt)	Road 90m.	Unlikely
T4b	T-Minor		1906	Level	4-6ft.thick		8905-2910	to separate by gravity.		Enclosure(Dirt Pitt)	Road 90m.	Unlikely
T4c	T-Minor		1882-1884	Levels		2126t.	8924-2914	Worked with zinc.				Unlikely
T4d	T-Minor						8925-2922					Unlikely
T5a	T-Minor	Wynch Bridge		Adit	2-4 ft. thick	Tested	9053-2767	32.9%Siderite	Minor cross veins off Teesdale	Quarry(Disused)	Pennine Way 30m.	Check
T5b				Levels	17 ft. thick		9072-2754			Tips(Disused)	Pennine Way 30m.	Check
T5c							9075-2750	Not economic		Tips(Disused)	Pennine Way 20m.	Check
T5d							9081-2745			Tips(Disused)	Pennine Way 20m.	Check
T5e							9085-2742				On Pennine Way	Check
T5f				Opencast and levels			9084-2754				On Pennine Way	Check
T6a	T-Orepit	Orepit holes	Ancient	Opencast	2600 ft. long		8756-2725 to	Evidence of smelting also	Remote minor veins		Track 120m.	Unlikely
T6b							8737-2728				Track 40m.No R of Way	Unlikely
T7	T-ParkEnd	Park End			Little ore		9280-2548		Park End. Parallel to Teesdale	Large quarry(Disused)	Near road	Unlikely

APPENDIX 6

(a) Whiteheaps - Was originally worked for lead in the 19th. century from two pairs of shafts. After an abortive attempt to commence production between 1921 and 1923 the mine was reopened by Blanchland Fluor Mines in 1938 and the stopes around the shafts were worked until 1962. British Steel then drove a new level and worked until the 1980's.

(b) Groverake - The Beaumont Company opened this mine for lead in 1819 and continued until 1883. The Weardale Lead Company mainly extracted lead in the period from 1884 to 1916 but also won some fluorspar. Serious production however began with the Allenheads Mining Company who took out 31,817 tonnes between 1901 and 1940. Thereafter British Steel refurbished the shafts and up to 1989 had recovered 695,341 tonnes of crude ore.

(c) Frazers Hush - SAMUK first opened up this mine from a drift which was taken over by Weardale Minerals and remains active at the present time.

(d) Redburn - Fluorspar was extracted by the Weardale Lead Company from a level commencing in 1964 and later from a shaft which up to 1977 produced 260,031 tonnes. SAMUK then worked the mine between 1977 and 1981, winning 68,774 tonnes.

(e) Boltsburn - Beaumont and then the Weardale Lead Company worked this mine for lead in three periods between 1818 and 1931, from levels and shafts, to recover some 124,000 tonnes of ore. In the latter phase from 1901 to 1931 some 7299 tonne of fluorspar was also won.

(f) Stotsfieldburn - The Rookhope Valley Mining Company extracted limited amounts of lead between 1863 and 1884 from shafts and a level. The Weardale Lead Company reconditioned the shaft for fluorspar in 1929 and thereafter won up to 4000 tonnes per annum until the shaft collapsed in 1938. Attention was then concentrated on the adit and a further 100,000 tonnes was produced up to 1957 when a new incline was driven which to 1966 allowed the mine total to increase to 275,392 tonnes together with some additional lead as a by-product. Limited opencasting also took place resulting in the extraction of a further 55,275 tonnes.

(g) Burtreepasture - This old lead mine was abandoned in 1890 until the shaft was refurbished by the Weardale Lead Company in the 1970's together with the sinking of a new sub-surface shaft but recovery was not economically viable. In 1977 SAMUK drove a new level and recovered reasonable tonnages but long term viability was again not possible and work ceased in 1981.

(h) Blackdene - The old lead mine, active from 1818 to 1861, produced some fluorite as a by-product when reopened between 1906 and 1939. Fluorite was also specifically extracted by J.V.Peart from 1936 until the workings collapsed to the surface in 1939.United Steel then opened up the old workings below the level and during British Steel's operation thereafter a new incline was driven to the surface. Until closure in 1987 over 300,000 tonnes of ore was produced.

(i) Barbary - Again a former lead mine from 1818 to 1872, the site was reopened by Blackwells between 1905 and 1935 using two new inclines from the surface to extract fluorspar. Weardale Lead Company reconditioned the mine in 1953 and worked fluorite until 1959.

(j) Cambokeels - Following unsuccessful trials here for lead which were abandoned in 1871, fluorite was produced from the Heights area above between 1905 and 1918, and again in the period 1925-1940 by a combination of a level and opencasting. Cambokeels was reopened in 1906 and worked for fluorite until 1939 under three owners producing

28,016 tonnes. In the late 1940's Anglo-Austral Mines reopened the main level and further development occurred in the 1970's with the driving of a new incline. More expansion took place under new owners from 1982 and good rates of production were maintained until 1987 with a total output, excluding Heights, of just under 500,000 tonnes of fluorite.

(k) Coldberry - The only fluorite production here has been by reprocessing the heaps at Broadwood and estimates put the resource at some 50,000 tonnes.

(l) Stanhopeburn - Ten owners have worked this area since the 18th.century, initially for lead and subsequently for fluorspar, beginning with the Earl of Carlisle. The London Lead Company then drove an adit, the Engine shaft and the Widley Level in their lease from 1816 to 1864. Further shafts associated with this development are referred to and shown on O.S. maps but are not referenced. Beaumont and then the Weardale Lead Company continued to work lead until 1933 but it was Beaston and Elliot in 1938-1940 who first extracted fluorite. This was continued by Fluorspar Ltd. and Laporte using the restored Widley Level until 1964. Ferguson and Wild again restored the level in 1971 but no significant production was achieved and SAMUK then reopened the Engine Shaft, using this between 1977 and 1982. The mine finally transferred to Weardale Minerals and is currently inactive.

APPENDIX 7

TABLE A

TYPE OF RECEPTOR	DESCRIPTION OF HARM
Human beings	Death, serious injury, cancer or other disease, genetic mutation, birth defects, or the impairment of reproductive functions. Disease is to be taken to mean an unhealthy conditions of the body or some part thereof.
Any living organism or ecological system within any habitat notified under section 28, declared under section 35 or designated under section 36 of the Wildlife and Countryside Act 1981[9], any European Site within the meaning of regulation 10 of the Conservation (Natural Habitats etc) Regulations 1994[10] or any habitat or site afforded policy protection under paragraph 13 of Planning Policy Guidance Note 9 on nature conservation or Planning Guidance (Wales): Planning Policy (that is, candidate Special Areas of Conservation, potential Special Protection Areas and listed Ramsar sites).	Harm which results in an irreversible or other substantial adverse change in the functioning of the habitat or site. (In determining what constitutes a substantial adverse change, the local authority should have regard to the advice of English Nature, Scottish Natural Heritage or the Countryside Council for Wales, as the case may be, and to the requirements of the Conservation (Natural Habitats etc) Regulations 1994).
Property in the form of livestock, of other owned animals, of wild animals which are the subject of shooting or fishing rights or of crops.	Death, disease or other physical damage such that there is a substantial loss in their value. For this purpose, a substantial loss should be regarded as occurring when a substantial proportion of the animals or crops are no longer fit for the purpose for which they were intended. In many cases, a loss of 10% of the value can be regarded as a benchmark for what constitutes a substantial loss.
Property in the form of buildings, where 'building' has the meaning given in section 336(1) of the Town and Country Planning Act 1990, that is, 'building' means any structure or erection, and any part of a building ... but does not include plant or machinery comprised in a building.	Structural failure or substantial damage. For this purpose, substantial damage should be regarded as occurring when part of the building ceases to be capable of being used for the purpose of which it is or was intended.

9 Sections 28, 35 and 36 of the 1981 Act relate to Sites of Special Scientific Interest, National Nature Reserves and Marine Nature Reserves, respectively.

10 SI 1994/2716. Regulation 10 relates to Special Areas of Conservation and Special Protection Areas.

TABLE B

DESCRIPTIONS OF SIGNIFICANT HARM TO RECEPTORS	CONDITIONS FOR THERE BEING A SIGNIFICANT POSSIBILITY OF SIGNIFICANT HARM
Effects on the health of humans from the intake of, or other exposure to, a contaminant.	If the intake by, or other exposure of, the humans involved as receptors in the pollutant linkage in question, over all or part of their lifetimes, of, or to, the pollutant in that linkage would be of an amount which would be unacceptable when assessed in relation to appropriate authoritative and scientifically based information on the toxicological properties of that contaminant (or, where such information is normally compiled by reference to a chemical class of contaminants, of that class). Such an assessment should take into account the relative contribution of the pollutant linkage in question to the aggregate intake of the relevant substance(s) by the humans concerned. Toxicological properties should be taken to include carcinogenic, mutagenic and teratogenic and other similar properties.
All other effects specified in Table A on human beings (particularly by way of explosion or fire).	If the level of risk of significant harm (as defined in relation to human beings in Table A), assessed in relation to appropriate, authoritative and scientifically based information relevant to the pollutant linkage in question, is unacceptable. Such an assessment should be taken into account the levels of risk of effects of the kind in question which have been judged unacceptable in other contexts.
All effects specified in Table A on any habitat or site mentioned in that Table.	If significant harm (as defined in relation to habitats and sites in Table A) is more likely than not to result from the pollutant linkage in question. An assessment for this purpose should take into account the relevant appropriate, authoritative and scientifically based information for the pollutant linkage in question, particularly in relation to ecotoxicological effects of the pollutant.

TABLE B (Cont'd)

DESCRIPTIONS OF SIGNIFICANT HARM TO RECEPTORS	CONDITIONS FOR THERE BEING A SIGNIFICANT POSSIBILITY OF SIGNIFICANT HARM
All effects mentioned in Table A on property in the form of livestock, of other owned animals, of wild animals which are the subject of shooting or fishing rights or of crops.	If significant harm (as defined in relation to such property in Table A) is more likely than not to result from the pollutant linkage in question. An assessment should be made for this purpose, taking into account the relevant appropriate, authoritative and scientifically based information for the pollutant linkage, particularly in relation to ecotoxicological effects of the pollutant.
All effects mentioned in Table A on property in the form of buildings, where 'building' has the same meaning as in that Table.	If significant harm (as defined in relation to such property in Table A) is such that it is more likely than not that such significant harm will result from the pollutant linkage in question during the maximum expected economic life of the building. An assessment should be made for this purpose, taking into account the relevant appropriate, authoritative and scientifically based information for the pollutant linkage in question.