BRITISH MINING No.63

MEMOIRS 1999

Williamson, I.A. 1999
"The Burnley Coalfield"
British Mining No.63, NMRS, pp.5-27

Published by the

THE NORTHERN MINE RESEARCH SOCIETY
SHEFFIELD U.K.

ISSN 0309-2199

THE BURNLEY COALFIELD:
Some geological influences upon the former mining exploitation and present-day development

by Iain A. Williamson

Coal mining at Burnley, northeast Lancashire, was first recorded in the late-13th century and, apart from occasional small ventures of insignificant effect, can be regarded as having ceased with the closure of Hapton Valley Colliery in 1982. Nineteen seams, all confined to the Lower Coal Measures (Langsettian Stage: Westphalian A), were at various times exploited although annual production seldom exceeded one million tons. Mining constraints were largely sedimentological although adverse effects of structural and hydrological origins were also experienced. Even the relatively high ranks of the principal coal seams, although financially advantageous, were at the same time disadvantageous in that such coals were often characterised by high gas emission rates and dusty conditions. The seams were relatively thin with mined-coal thicknesses usually less than 1.5 metres. Other deleterious effects resulted from the shallow depths of the highest coals beneath the Burnley town centre and the thick unconsolidated alluvial deposits of the Calder floodplain. Geological problems were also encountered during the working of a lead vein in the early 17th century and even the smelting process caused an early complaint of smoke pollution.

Former shallow mine workings still present a subsidence risk necessitating often lengthy site investigations and subsequent ground treatment prior to any modern urban renewal. Some 640 former mine shafts and drift entrances are at present recorded and in many cases their exact positions can only be found after extensive investigations. Upon the surrounding upland areas a number of self-draining drift-mines result in the pollution of the adjacent streams and rivers. A very slight prospect exists in the coalbed methane potential of the coalfield.

INTRODUCTION

The Burnley Coalfield (Fig. 1) is part of an elongated structural basin with the longer axis trending east-north-east from Blackburn to the Yorkshire border beyond Colne. The northern and southern flanks are formed by the Pendle Monocline and Rossendale Anticline respectively. The Pennine Anticline forms the eastern flank whilst the northerly trending Altham/Huncoat Fault is arbitrarily taken as the western limit, beyond which lies the smaller Accrington Coalfield. Similarly the Deerplay and Hameldon Faults delineate the coalfield from the horizontal strata of Rossendale to the south. The topography mirrors the geological structure (Plate I) in that the central part between Padiham and Colne, as followed by the M65, lies within the valleys of the Lancashire Calder and the lower reaches of Pendle Water, whilst the Rivers Brun and Don flow from the Pennine moorlands to the east.

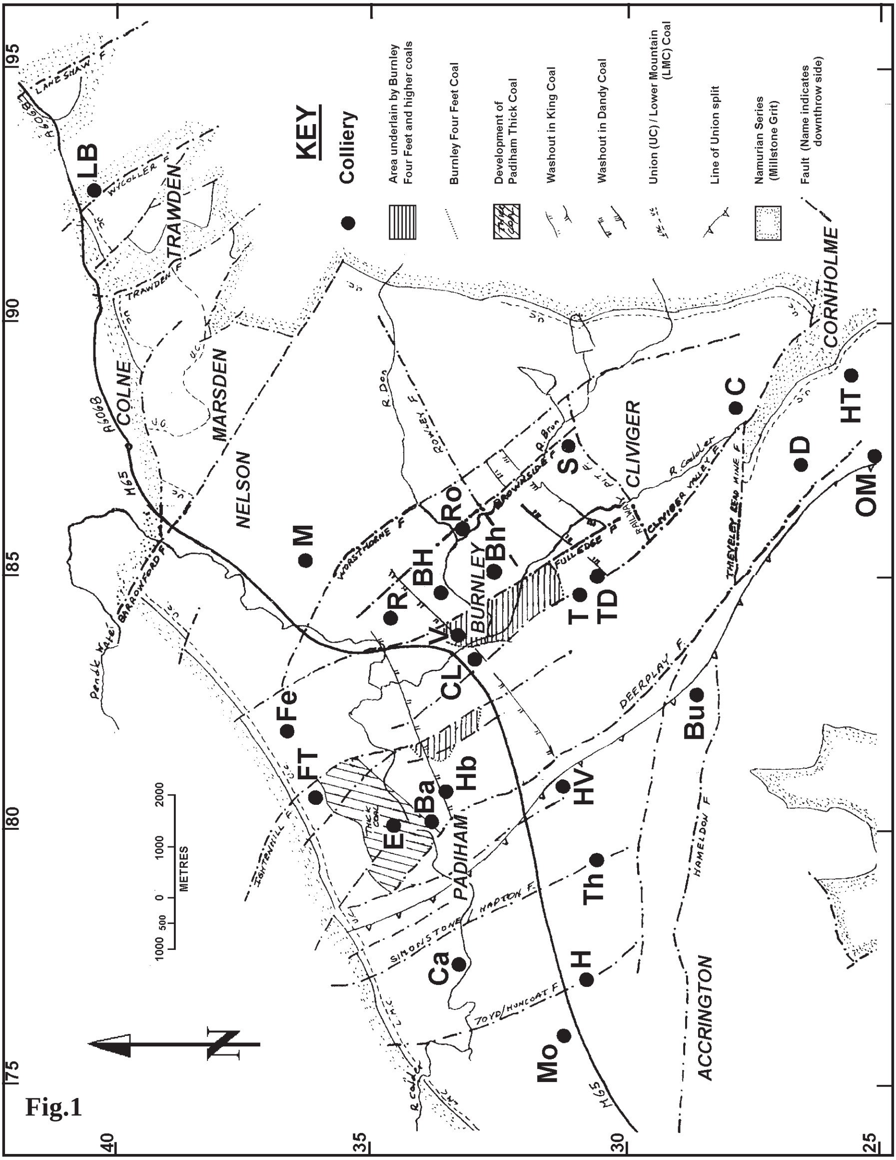
KEY
Colliery
Area underlain by Burnley Four Feet and higher coals
Burnley Four Feet Coal
Development of Padiham Thick Coal
Washout in King Coal
Washout in Dandy Coal
Union (UC) / Lower Mountain (LMC) Coal
Line of Union split
Namurian Series (Millstone Grit)
Fault (Name indicates downthrow side)
METRES
1000 500 0 1000 2000
COLNE
TRAWDEN
MARSDEN
NELSON
BURNLEY
CLIVIGER
CORNHOLME
PADIHAM
ACCRINGTON
LB
M
R
BH
Ro
Bh
S
C
D
HT
OM
T
TD
V
CL
Fe
FT
E
Ba
Hb
HV
Bu
Th
H
Ca
Mo
M65
95
90
85
80
75
40
35
30
25

Fig.1

Fig.1. Simplified map of the Burnley Coalfield. Collieries referred to:-

Ba	– Bankroft	BH	– Bank Hall	Bh	– Bee Hole
Bu	– Burnt Hills	C	– Copy	Ca	– Calder
CL	– Clifton	D	– Deerplay	E	– East
Fe	– Fence	FT	– Fir Trees	H	– Huncoat
Hb	– Habergham	HT	– Hill Top	HV	– Hapton Valley
LB	– Laneshaw Bridge	M	– Marsden	Mo	– Moorfield
OM	– Old Meadows	R	– Reedley	Ro	– Rowley
S	– Salterford	T	– Towneley	TD	– Towneley Drift
Th	– Thorneybank	V	– Vicarage.		

Faulting is extensively developed and a series of northwesterly trending faults with downthrows of up to 400 metres (Cliviger Valley Fault) dominate the field. Several easterly trending structures also occur and the displacement of one, the Thieveley Lead Mine Fault, reaches c.275 metres.

***PLATE I**. North-easterly view from Rosehill Road across the centre of Burnley to Marsden Heights. The Victorian terraced housing in the foreground reflects the dip slope of the southern flank of the coalfield basin. Beyond, in the town centre, under which the shallowest coals occur, the horizontal roof lines of the Fulledge area behind the Leeds/Liverpool Canal similarly reflect the horizontal strata in the centre of the basin. In the distance the recent housing estates are developed upon the dip slopes of various sandstones occurring upon the northern flank. Formerly there were over 100 mill chimneys visible from this viewpoint; the two remaining chimneys clearly attest to the demise of the former 'King Coal' as a major power source.*

Unlike in south Lancashire only the Lower Coal Measures (Langsettian Stage: Westphalian A) remain at Burnley. Accordingly, whereas in the former area the major productive sequences were confined to the upper part of the Lower, and the Middle (Duckmantian Stage: Westphalian B) Coal Measures, the Burnley collieries exploited several towards the base of the Coal Measures which elsewhere, excepting the Arley Coal, were but little worked. Indeed it was simply a case of ‘needs must’ to survive in that the thinnest coals would not have been worked had other thicker seams been available. Nevertheless several seams, most notably the Lower Mountain, Upper Mountain and Arley Coals were low volatile, high grade metallurgical cokingtypes of exceptional quality and considerable industrial importance beyond the confines of the coalfield. Again the coalfield differs from that of south Lancashire in that it is totally exposed whereas the latter becomes concealed southwards beneath an unconformable cover of Permo-Triassic strata. Consequently, and particularly in the low-lying parts, the seams incrop against the base of unconsolidated glacial or more recent alluvial sediments. Such deposits often caused especially hazardous conditions during the working of the shallowest coals in the early and mid 19th century.

THE COAL SEAMS: SEDIMENTOLOGICAL CONSTRAINTS

Of the 19 coal seams worked (Table 1) the Lower Mountain/Union, Upper Mountain, Arley, Dandy and King Coals were most exploited.[1] This was particularly so during the last 100 years prior to which reserves of the higher and shallowest seams became exhausted in the early part of the Industrial Revolution. Adverse sedimentological conditions were mainly encountered during working the Lower Mountain/Union, Dandy and King Coals.

(a) THIN SEAMS

Most seams seldom exceeded 1.5 metres thickness. Indeed sometimes, as in the Cannel Coal workings at Laneshaw Bridge Colliery (SD926404), the thickness was only 0.5 metre. Accordingly, and excepting for the occasional additional extraction of the underlying fireclay – seatearth for the manufacture of refractory products as at the Upper Mountain and Union horizons of the Towneley Drift (SD850306), thin seam working, with all its attendant physical hardships, was the norm. Regrettably the thin seams were a strong inducement to use child labour until the Act of 1842 prohibited the employment of children below the age of 10 in underground workings. Previously children of both sex were employed as ‘*drawers*’ or ‘*pushers*’ for hauling coal throughout the workings to the pit bottom. Their hardships, for the “*want of sufficient roof height*”, were graphically described so that “*every person of feeling will pity those poor children whose position in life has caused them to be subject to it*”.[2] Thus for a weekly wage of four shillings (20 pence) a seven year old boy, working eight hour shifts, pushed tubs of coal along one metre high roadways for distances of 135-180 metres in the Shell Coal at Vicarage Colliery (SD873334). Conditions were even worse at Burnt Hills Colliery (SD828286) where roadways in the Lower Mountain Coal were only 0.76 metre high, although in this instance the

TABLE 1. Sequence, thickness (as worked) and general interseam intervals of the worked coal seams in the Burnley Coalfield.

Seam	Thickness (m)	Interval (m)
Doghole Rider(1)	0.8	6.0
Doghole	1.5-1.9	6.0
Kershaw	1.1	15.0
Palace House Top(1)	1.2	4.0
Shell	0.8-1.1	3.0
Burnley Four Foot	1.2	8.0
Maiden	0.9	48.0
Lower Yard	0.9	25.0
Blindstone	0.7-1.3	13.0
Fulledge Thin(2)	0.8-1.0	36.0
King(2)	1.4-2.2	60.0
China	0.6	32.0
Dandy	0.5-1.7	45.0
Arley	0.8-1.5	160.0
Pasture	0.5-1.0	56.0
Cannel(3)	0.5	7.0
Upper Mountain	0.5-1.0	40.0
Union(4)	0.8-1.5	26.0
Bassy	0.6	

1. Opencast working only.
2. At Padiham the Fulledge Thin and King Coals unite to form the Padiham Thick seam (c.3.5m).
3. This well established seam name is confusing. Apart from the occasional occurrence of a thin band of cannel towards the roof the seam usually consists of normal bituminous coal.
4. South west of Burnley the Union Coal splits into the Lower Mountain Coal (0.7 m) and Upper Foot Coal (0.3m).

youngest drawer was 13 years old. Fortunately at the Marsden Higher Pit (SD855361) the Arley Coal attained 1.2 metres thickness so that there was "*no necessity for young children*" to act "*as drawers*".

Even in the 1950s underground transport was still occasionally restricted by low roof heights so that at the Old Meadows Colliery (SD869239) the coal was hauled along 1.2 metre high roadways up to closure in 1970. The combination of thin seams and low roadway heights adversely affected coal output which is always limited to the capacities of the coal haulage and shaft winding systems. Until the mid century much of the coal was transported underground, and also in some instances for considerable distances on the surface, by an endless chain system hauling small tubs or 'jinney wagons' with individual capacities of only 4.5 to 15 hundredweight (229 - 760kg). The system, almost unique to the coalfield, was particularly suitable to thin seam conditions before the use of conveyor belts. Sadly however it resulted in a disproportionate number of accidents to the haulage 'minders' or 'tenters' who, in such restricted spaces were sometimes dragged into, or crushed by, the passing wagons. In the first decade of this century almost 50% of the underground fatalities could be attributed to such causes.

(b) SEAM SPLITS

Upon the western edge of the coalfield the Union Coal splits into the Upper Foot and Lower Mountain Coals along a line (Fig.1) west of the approximately parallel and clearly related Deerplay Fault (extending northwards as the Padiham Fault, Fig.2).[3] The faults are considered to be reactivated growth structures although the original westerly displacement, as evidenced by the split became reversed during the later major movements.[4] Economically the split has a considerable effect since the Lower Mountain is a low ash, low sulphur and prime coking coal whilst the Upper Foot and Union Coals are highly sulphurous and, therefore, unsuitable for the production of metallurgical coke. Their high sulphur content probably originated from the contamination of the original peat mire by the marine incursion evidenced by the *Listeri* Marine Band forming their common roof. Most of the Lower Mountain Coal was worked out prior to the nationalisation of the coal industry in 1947. The remaining reserves were accessed from Thorney Bank Drift Mine (SD792306), driven in 1954 and abandoned in 1967, and also from Calder Colliery (SD772331). Here the coal face was sometimes as low as 0.7 metre although some alleviation of the difficult physical conditions was gained by 'ripping' an additional 0.9 metre of shale above the main haulage roads. The exceptional quality of the coal and the contemporary demand for metallurgical coke was so strong that, although Calder Colliery made a considerable financial loss throughout its final years, output continued until the reserves were totally exhausted in 1958.

Fig. 2. Plan of Lower Mountain Coal workings in Calder Colliery illustrating distribution of rigs and their relationship to seam contours, the Union split and the Padiham Fault.

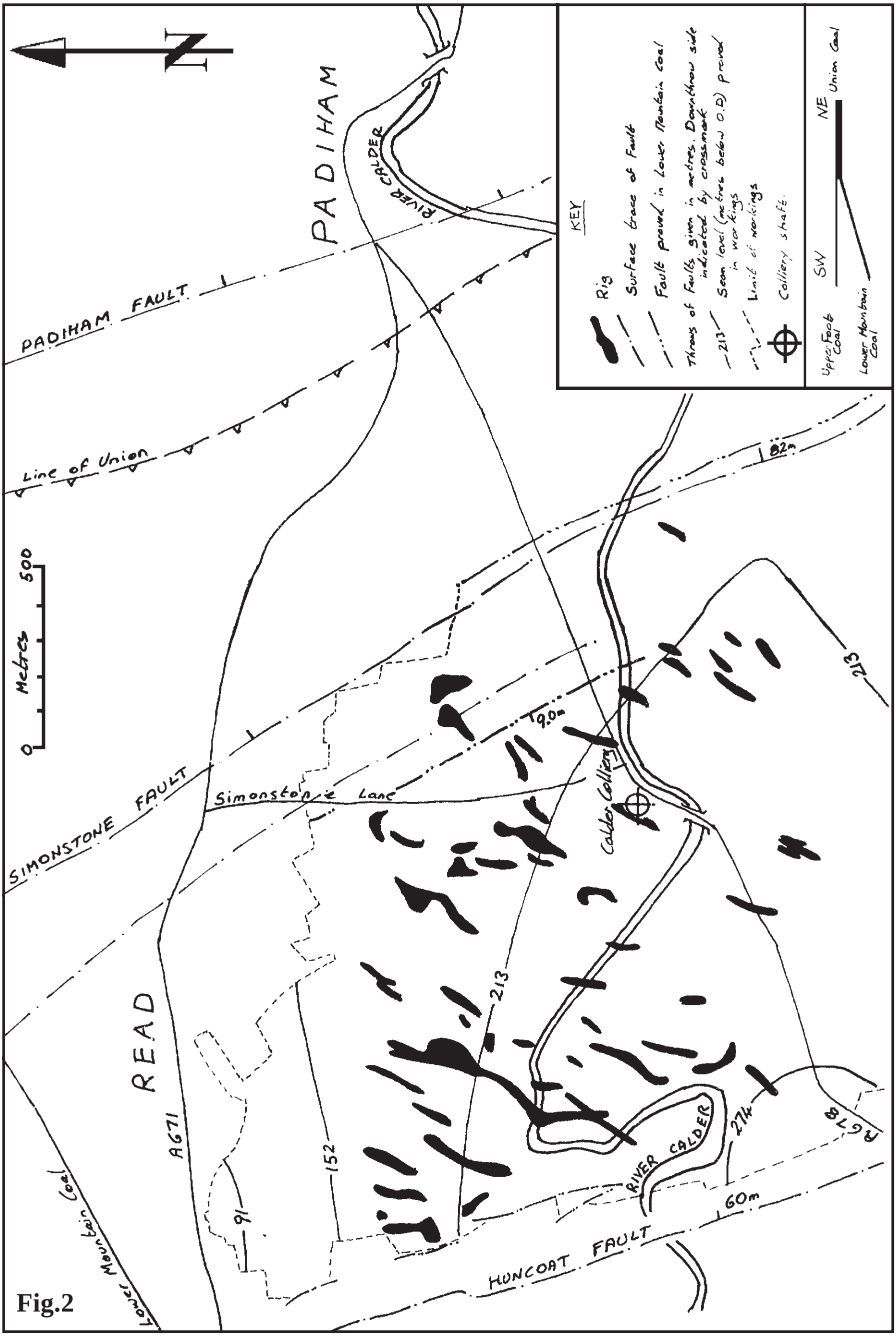
N
PADIHAM
RIVER CALDER
PADIHAM FAULT
Line of Union
Metres
0
500
SIMONSTONE FAULT
Simonstone Lane
9.0m
82m
213
Calder Colliery
READ
A671
152
91
274
60m
HUNCOAT FAULT
A678
Lower Mountain Coal
KEY
Rig
Surface trace of Fault
Fault proved in Lower Mountain Coal
Throws of Faults given in metres. Downthrow side indicated by crossmark
213 Seam level (metres below O.D) proved in workings
Limit of workings
Colliery shaft
SW
NE
Union Coal
Upper Foot Coal
Lower Mountain Coal

Fig.2

The Lower Mountain Coal for some 2000 metres west of the Union split is locally affected by occurrences of 'rigs' composed of masses of cannel coal and/or canneloid shale infilling generally elongate depressions in the seam. In such areas the seam was sometimes too thin, or alternatively difficult to work, since the highly listric natures of the rig/coal contacts resulted in weak roof conditions. The rigs appear to have formed upon the westerly inclined palaeoslope ending the formation of the Lower Mountain Coal. Many, showing a sub-parallel or parallel alignment with the line of split, are attributed to deposition within a series of linear pools caused by downslope creep of the peat mire.[4] Others, however, as encountered at Calder Colliery (Fig.2), exhibit a marked parallelism with the stratal dip which is at least suggestive of the contemporaneous development of the coalfield basin.

In contrast to the above deleterious effects the 'union' of the King and Fulledge Thin Coals to form the Padiham Thick Coal favoured several highly successful mining enterprises north of Padiham (Fig.1). Here the combined seam exceeded 3.5 metres of generally low ash, good quality coal over an area of c.390 ha where the Tim Bobbin Rock (sandstone), usually comprising the bulk of the interval between the two seams, is absent.[5] Since the seam occurs at very shallow depth it formed a most attractive prospect in the mid-19th century. A number of small collieries, with shaft depths of only 28.0 metres to c.50.0 metres, situated upon the edge of the Calder floodplain, were highly profitable ventures for both the mine and mineral royalty owners. Thus, during six months in 1863, the East (SD800344) and Bankroft (SD799338) Pits, together employing only 76 men, mined over 33,000 tons of coal. Their Output per Man Shift (OMS) of c.3.3 tons was over three times that of the British coal industry at nationalisation in 1947. The coal sold for £22,000 (at present day prices the sale would have yielded over £1 million). During the same period the colliers' wages and Royalties paid to the Gawthorpe Estate were respectively £1173 and £2300: a handsome profit indeed. As elsewhere the occurrence of such thick coal at shallow depths became a great temptation to work beyond safe limits. In 1860 the remnant pillars, left to support the roof of previous workings, were being 'robbed' below the Calder floodplain (SD804342). Since over three metres of coal had already been extracted at only 20 metre below the base of 12 metres of "*sand, marl, loam, wet sand and gravel*" it is hardly surprising that the roof collapsed.[6] An influx of "*water, sand and gravel*" blocked the workings "*to a considerable distance towards the shafts*" so that "*the workmen escaped in a great hurry*". The last remnants of the Padiham Thick Coal were finally removed by opencast mining in the mid 1950s. Several sites were worked and that west of Whitaker Clough (SD803347) yielded 480,338 tons from the support pillars alone of the original colliery abandoned after an influx in 1818. Although the opencasting of previous workings in such a thick seam were obviously profitable other sites, working thinner seams, and particularly in the immediate post war years, were seldom so successful. At some the few prospecting boreholes which were then drilled failed to reveal the widespread extent, or sometimes even the occurrence, of previous mining activities. The 1949 opencast workings in the thin Blindstone Coal at the Ridge Site (SD856332), with coal/overburden ratios of 1 in 10, cannot have been profitable since over 50% of the anticipated reserves had already been mined in the 16th century.

(c) IN-SEAM CONCRETIONS

The Union Coal is frequently contaminated by spherical or ellipsoidal limestone concretions composed predominantly of fibrous calcite together with some pyrite and bituminous matter.[7] Such coal balls, or 'bobbers', usually about 0.1 to 0.2 metre diameter, although sometimes reaching 1.0 metre diameter, contain a wealth of plant fossils with perfectly preserved anatomical detail. Numerous specimens from the Burnley collieries were used by Marie Stopes in her pioneering palaeobotanical studies.[8] Then, in 1900, in contrast to 60 years earlier, women were seldom tolerated underground so that she had to adopt a male disguise before visiting and collecting from the Union Coal workings at Bank Hall and Hapton Valley. Whilst of considerable palaeontological interest, the concretions, sometimes occurring in large clusters and persisting for some distance along the coal face, resulted in troublesome conditions experienced during machine mining as distinct from 'hand getting'.[9] Indeed in 1971 their occurrences were largely responsible for the closure of Bank Hall (SD846336), Burnley's deepest (No.1 Pit Shaft depth: 482 metres) and then largest colliery with a yearly saleable coal output of over 300,000 tons. Prior to abandonment the workings had extended for over 4.5 km 'inbye' of the access shafts in central Burnley to beyond the Railway Pit Fault at Cliviger. Over such underground distances the ventilation, of what were always potentially hazardous, 'gassy' workings, was becoming difficult. After eight methane ignitions at the coal face, caused by incendive sparking as the cutter picks struck the pyritic coal balls, the colliery, employing 800 men, was closed. Over eight million tons of Union Coal reserves in the triangular area between the Worstborne, Railway Pit and Cliviger Valley Faults were thereby abandoned. Although the acute ventilation problems could have been eased and a much reduced, and therefore more profitable, coal haul could have been effected, and had been considered, by the driving of an inclined access tunnel from the surface at Cliviger the coal quality was such that the venture could not be justified. Already the highly sulphurous nature of the Union Coal was becoming an environmental embarrassment.

(d) ROOF CONCRETIONS

The shale roof, formed by the *Listeri* Marine Band, of the Union Coal contains large ovoid bituminous limestone concretions or 'bullions' hence the synonym – Bullion Coal. The bullions are considerably larger than the coal balls and sometimes exceed 1.5 metres diameter and can weigh several tons. Although containing plant fossils, again perfectly preserved, the bullions are especially characterized by a well preserved, often solid and usually pyritized marine fauna composed of goniatites (mainly *Gastrioceras listeri*), marine lamellibranchs (eg. *Dunbarella papyracea*, *Posidonia gibsoni*) and rarer nautiloids. Especially large specimens of *G. listeri* were often collected by the colliers and many old Burnley mining families still possess fine 'door stoppers' formed by a pyritized goniatite up to 0.1 metre diameter. Above the coal face the existence of a bullion was sometimes revealed by a slight iron-stained blister in the roof. In such cases they could be safely supported by a prop or, alternatively, dislodged. Unfortunately they were not always so obvious when their sudden collapse caused several fatalities and numerous lesser accidents.

Since both bullions and coal balls are confined to the Union, or the Upper Foot horizons their origins would appear to be at least partly related to the marine incursion associated with the *Listeri* Marine Band. However, although a marine origin for some of the carbonate material is accepted, recent studies would also suggest partial derivation from meteoric sources.[10]

(e) WASHOUTS AND PARTINGS

The Dandy Coal was extensively worked despite being prone to the development of dirt partings within the upper part of the seam. Often the top coal was unworked and left in the roof. Even then the pithead product had a high ash content (averaging 11.5% at the Salterford No.2 Colliery: SD874310) and encountered consumer resistance. The horizon was only worked in the various collieries after exhaustion of the underlying renowned Arley Coal. Significantly at Bank Hall, Reedley and Habergham Collieries the seam was renamed as the Upper Arley (a similar attempt to market another relatively inferior coal, the Blindstone, was also made during the late stages of Habergham Colliery in 1939 when the coal was sold, understandably with little success, as the Arley Yard!). The Dandy Coal is rendered totally uneconomic by the occurrence of thicker partings along a 300 metres to 500 metres wide zone (Fig.1) between Towneley, Rowley and Salterford Collieries. Towards the centre of the zone the seam becomes totally washed out by the descent of a sandstone which usually occurs a few metres above the shale roof. At current prices the potential revenue loss of even such inferior coal would amount to some £50 million.

As distinct from the above washout developed as an erosional feature almost contemporaneous with the original peat mire, a more recent 'glacial washout' was encountered in the Dandy Coal at Copy Colliery (SD885275) in 1963. Here a narrow heading was being driven to access the remaining coal reserves. Suddenly the shale roof passed into a wet mass of sandy clay and gravel which partly washed out the underlying coal.[11] Progress was immediately stopped to enable a series of investigatory boreholes to be drilled. The heading was shown to have just penetrated the base of a pre-glacial (Devensian) valley which had been subsequently infilled by glacial deposits. Since the cost of protective works, to prevent a possible influx of the unconsolidated deposits into the workings, could not be justified by the coal reserves the 135 year old colliery was abandoned.

The most extensive washout, resulting in the loss of over seven million tons of King Coal, affected a broad front up to two kilometres wide between Bank Hall and Reedley, and Hapton Valley and Habergham Collieries Fig.1. The feature trends east north east, parallel to the main washout in the Dandy Coal and also to the long axis of the coalfield basin. It coincides with the major development of the Tim Bobbin Rock, a cross-stratified, fine-grained sandstone, which rapidly thickens towards the washout. Thus at the Bee Hole Colliery (SD851325) it was only 10 metres thick whilst a mile northwards, on the edge of the washout at Bank Hall Colliery the sandstone had thickened to 31 metres and at Clifton Colliery, where the coal was absent, the sandstone exceeded 40 metres.[5]

Excepting the Arley, Union and Lower Mountain Coals, 'dirt' partings, often composed of carbonaceous mudstone, 'fireclay' mudstone and, less commonly, siltstone, are of frequent occurrence in all the worked seams. Although usually less than a few centimetres they sometimes comprise over 20% of the worked seam thickness. Even then, as in the King workings at Bank Hall and Towneley Collieries, the seam was still profitably exploited. The King Coal parting is clearly related to and contemporaneous with the washout affecting the seam. It noticeably thickens from c.0.1 metre of carbonaceous mudstone over most of the coalfield to 0.6 metre of siltstone at the actual washout. Another parting, the 'blindstone' in the seam of that name is especially interesting in its particularly siliceous nature. Occurring consistently towards the top of the seam, it appears as a dark brown, 0.05 metre thick, hard, coaly siltstone. The band, identified as a quartzlagen by Hoehne, is predominantly composed of granular and acicular quartz sometimes interlaminated with bright coal.[12] Other occurrences occur towards the roof of the Union Coal at the former Old Meadows Colliery (SD883243) and at Cornholme (SD897250). Fortunately they are rarely encountered since their highly siliceous natures are conducive to incendive sparking, with explosive potential in gassy workings, when cut by machine mining. Although appearing, at least in part, to have formed by the in situ precipitation of quartz their precise origins are uncertain.[13]

'Dirt', in mining parlance equates with 'spoil heaps', often incorrectly termed 'slag heaps'. Whilst the largest have been totally restored, so that the former tip complex associated with Bank Hall Colliery now forms part of the attractive Rowley Amenity Area (SD860331) a visual reminder of the immense volumes of spoil generated by former mining still remains at Causeway End (SD848311). Here one of the smallest of the Towneley Colliery tips, despite some attempt at afforestation, is still a most prominent feature above Todmorden Road. As in other industrial areas the occasional tip was used to advantage by the local football spectator. In this respect that of the former Bee Hole Colliery (SD850325) was, until it was only recently replaced by a magnificent stand, patronised by some of the more vociferous supporters of the Burnley Football Club at Turf Moor. Here the 'Bee Hole End' was the local equivalent of Liverpool F.C's more famous 'kop'. Whilst considerable quantities of spoil originated from the interseam strata, 'ripped out' during access road and interseam tunnelling, the largest amounts were derived from the coal preparation plants where the '*run of mine coal*' was washed and screened prior to marketing. Since many collieries worked the Union Coal with its associated pyritic marine roof strata some of the tips, additionally containing some residual small and impure coal, were most liable to spontaneous combustion. Their sulphurous reek was a constant reminder that whilst their surfaces often appeared to be solid the tips were sometimes incandescent a few metres below ground level. Indeed a particularly tragic accident occurred in the early 1950s when two children were playing on the Rowley tip when the congealed crust collapsed.

HYDROLOGICAL CONSTRAINTS

Apart from Bank Hall Colliery, where at over 500 metres depth the Union Coal workings were both dry and dusty, most of the workings in that and overlying seams were comparatively shallow and consequently prone to considerable makes of water. So much so that the writer vividly remembers visiting Deerplay Colliery a few weeks before closure in 1968 when the Union Coal was being worked up to the Deerplay Fault. The water feeders pouring out from the heavily fractured ground at a depth of 160 metres were so strong that yellow oilskins were worn so that the scene bore a greater resemblance to nocturnal deep sea fishing rather than a coal face.

It is not surprising that even in mediaeval times reference was frequently made to difficulties in soughing and draining the shallow workings along the hillside outcrops of the Arley and Union Coals. Such mines were worked by a series of shallow shafts, seldom over 40 metres depth, behind the outcrop and drained from a sough or 'water loose' along or below the outcrop. Many of the early mining leases emphasised the right to drive soughs from some distance from the actual workings. In such cases, when the seam dipped into the hillside, a greater area of coal could be dewatered than from a tunnel only driven from the actual outcrop. Often, despite such drainage works, mining was a "*highly seasonable activity being confined to Summer and Autumn*" when the water table was low.[14] Even so many such early ventures were abandoned due to flooding. Their water yields increased exponentially with the progression of the workings and development of roof fractures tapping shallow aquifers or, sometimes, the actual land surface. Frequently as the workings progressed from the outcrop the stratal dip ultimately carried the seam to a level below that of the sough outlet. Thus at Carry Heys, Colne (SD c.898394) Lawrence Towneley in the early 17th century was forced to abandon his mine in the Union Coal because "*the current of water could not be drawn off the coal in regard to the coal bed dibbed* (sic) *into the hills, notwithstanding all their best efforts to dry the same*".[15] Even 300 years later the proprietors of the proposed Calder Colliery were forced to abandon shaft sinking for several years after artesian conditions were encountered in the Old Lawrence Rock (sandstone) in 1903. The shaft flooded and was only completed to the Union Coal in 1907.

As a result of the shallow natures of the higher seams, the occurrence of numerous sandstone aquifers and the considerable degree of faulting, the water tonnage pumped and drained from the Burnley workings considerably exceeded that of coal. In the late 1950s at Huncoat Colliery the pumps were sometimes lifting over seven million gallons a week (31,250 tons) from the Upper Mountain workings at 200 metres depth when the weekly coal production varied from 3500 to 5500 tons. Similarly in 1892 at Clifton Colliery a pumping rate of around four million gallons/week (c.18,000 tons) was recorded from the Arley workings at 280 metres depth when the weekly coal production was only 2000 tons. It was sometimes even necessary to continue pumping after abandonment where the former workings were either interconnected with a working colliery or only separated by a barrier of unworked coal which, as the water level rose, would be insufficient to withstand the increasing hydraulic head. Towneley Colliery, which ceased production in 1948, continued as a pumping pit until 1968 to safeguard the deeper workings at Bank Hall which became abandoned in 1971. The latter colliery was similarly protected by continuous pumping until 1969 at Clifton Colliery where mining had ceased 14 years previously.

STRUCTURAL EFFECTS

The north western and eastern edges of the coalfield are characterised by narrow zones, up to 1.5 km wide, of steep strata with dips sometimes exceeding 1 in 3 (18º). The Arley and underlying seams are most affected. Consequently, although some mediaeval bell pitting took place, such ‘Rearing Mines’ were hardly exploited until the flatter, more easily mined, areas became worked out.[16] Accordingly it was not until the 1950s that the Arley Coal, cropping out north of Padiham, became worked from several small drift mines at Fir Trees (SD806361) and Fence (SD818365). Elsewhere seam gradients seldom exceed 1 in 6 (9º) and are less than 1 in 10 (5º) in the central parts of the basin.

Most of the coal reserves were extracted before the mid-1950s so that hand getting, when the coal was chiefly worked by an air pick and shovel, prevailed. Nevertheless such a simple system, although limiting the OMS as compared with that attained by mechanised mining, was particularly suitable for some of the local conditions where the seams were affected by minor faulting and overlain by variable roof strata. However to satisfy the increasing energy demands of the immediate post-war years the collieries were considerably reorganised and more sophisticated mechanised mining methods were introduced. Whilst production improved, as at Bank Hall Colliery, when between 1954 and 1959 production increased from 183,687 ton (OMS: 19.1 cwt/970.3 kg) to 292,569 tons (OMS: 26.7cwt/1356.4 kg), some former reserves in lightly faulted ground were abandoned as unworkable.

From the early 19th century many of the large north westerly trending faults formed natural limits to the individual colliery takes. Thus the Ightenhill Fault (downthrow c.200 metres west) was the boundary between Habergham and Clifton Collieries, the Seventy Yard/Huncoat Fault (c.82 metres east) limited the workings of Huncoat Colliery from those of Moorfield Colliery in the Accrington Coalfield, and the Bank Hall Colliery workings terminated northwards against the Worsthorne Fault. From the '*barren ground effect*' the faulting resulted in a considerable reduction of the available reserves. At Hapton Valley Colliery the effect of the Deerplay Fault (downthrow c.160m east) reduced the Union Coal reserves (Fig.3) by approximately 1,500,000 tons which at current (October 1998) pithead prices would sell at c.£36,000,000. Similarly, from consideration of the Mine Abandonment Plans, the Fulledge Fault (c.100m west), reduced the reserves of the much higher grade Arley Coal by over 500,000 tons (c.£25,000,000) between Bank Hall, Reedley and Clifton Collieries (Fig.4) whilst the Brownside Fault (30 metres west) caused the loss of 300,000 tons (c.£15,000,000) of the Arley at Bank Hall and Rowley Collieries.

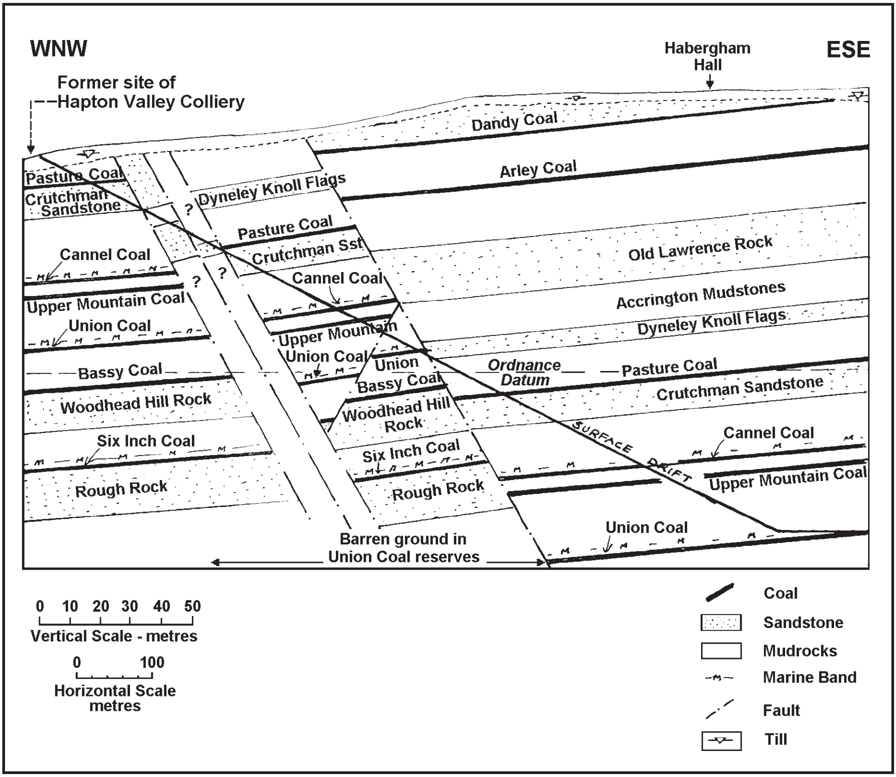

Fig.3. Horizontal section along the Surface Drift inclined from Hapton Valley Colliery to access Union and Upper Mountain reserves east of the Deerplay Fault. Due to faulting the coal was absent across a 450 metre wide zone of 'barren ground'.

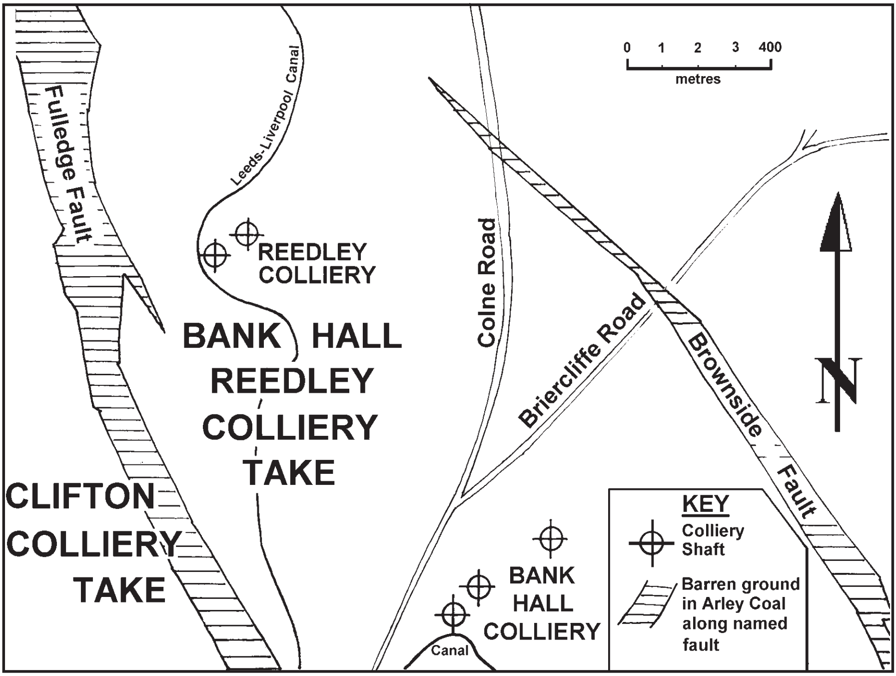

Fig.4. Barren ground associated with the Fulledge and Brownside Faults encountered in the Arley Coal workings of Clifton, Bank Hall and Reedley Collieries.

Conversely the juxtaposition of different seams by faulting lessened the necessity for the driving of long, capital consuming, cross-measure tunnels through the interseam strata. The Cliviger Valley Fault (here c.365 metres east) was, in 1871, encountered close to the Towneley Colliery shafts (Fig.5) so that the Union and Upper Mountain Coals were worked west of the fault and the Arley and higher coals to the east. The much deeper Union Coal on the downthrow side was subsequently accessed in 1957 via the Towneley Tunnel from Bank Hall Colliery. Unfortunately at Rowley Colliery the Brownside Fault, when encountered at 61 metres to 86 metres depth, caused difficult shaft sinking conditions. The crush effects of the highly fractured strata in the fault zone were always noticeable as a distinct buckle in the shaft used for pumping and man riding. Such a distinct kink thereabouts resulted in a notoriously uncomfortable ride.

RANK, GAS AND DUST

The basinal nature of the coalfield, combined with a former burial depth below at least some 3000 metres of once overlying strata, resulted in the formation of high rank coals. The Lower Mountain, Upper Mountain and Arley Coals are especially noteworthy for their prime coking natures. However although such properties considerably enhanced their value,

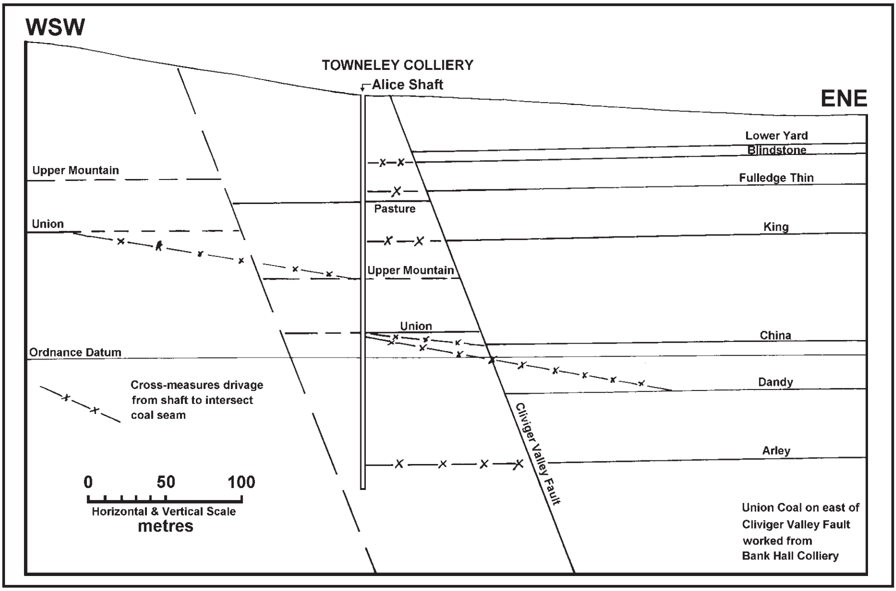

Fig.5. Alice Shaft section, Towneley Colliery, illustrating coal seams accessed by cross-measure drivages across faulted ground.

primarily as sources of metallurgical coke, they are also associated with particularly high 'gassy' conditions in the deeper collieries. Indeed very high firedamp (consisting of 80-95% methane) yields were frequently recorded, although that of 113 m^3/ton in the Union workings of Bank Hall Colliery can only be regarded as highly exceptional and short lived.[17] The explosive potential of the normal yields could only, initially, be suitably combated by the use of powerful ventilation fans which were then concomitant with very high air velocities circulating around the mine workings. Unfortunately a corollary associated with such efficient ventilation was the accompanying dispersion of dangerous amounts of airborne respirable dust. Accordingly whilst the explosive dangers became reduced Burnley was, sadly, notorious for the prevalence of pneumoconiosis amongst the older mine workers.

Since the late 1950s, in addition to ventilation, methane generation was controlled by draining the gas from the surrounding strata before it could escape into the workings. The technique involves a continuous programme of angled boreholes drilled close to the coal face and piping the gas directly to the surface. It was not surprising that in 1957 Bank Hall, together with Point of Ayr in North Wales (a similarly gassy mine), became the first collieries to commercially operate large scale methane drainage plants. In view of the high methane emissions credit must be given to the skills and cares of the past colliery managers in that Burnley, unlike other coalfields remained free from any major underground explosion until 1962.[18] Then, at Hapton Valley Colliery, 19 men were killed and 13 others were seriously injured in a methane explosion in the Union Coal workings.

LEAD MINING

About 1626 galena was discovered upon the northern slopes of Deerplay Moor above the Cliviger Gorge at Thieveley (SD873278). Only limited amounts of ore occurred sporadically along the westerly trending Thieveley Lead Mine Fault.[19] Even during the main period of mining, from 1629 to 1635, less than 150 tons of galena were raised. Such a paucity being a partial reflection of the insoluble natures of the coal measure wall rocks which would inhibit the development of any replacement ores. Again the presence of thick shale sequences would favour the formation of clayey gouge along the fault walls so that open fissuring, suitable for any subsequent mineralisation, would be unlikely. Significantly, in 1631, Thomas Braye, a mining consultant from Eyam, Derbyshire, pessimistically reported that this "*mine att Clevager is contrarie to our mines in our cuntry, for itt lies in the greetstone, and our mines all are in the limestone, and mingled with cauke* [baryte] *and keavell* [calcite] *as wee call itt, which makes our oare worke better than this will doe of ittselfe, for this lieth in a black shale and is very pure*".[20] Mine drainage, as in the contemporary coal mines was both difficult and expensive, particularly since the Rough Rock, the coarse-grained 35 metres thick uppermost Namurian sandstone, would form the footwall of the lowest workings. This well jointed sandstone would most likely be saturated at such depths and would, after the stripping of the fault gouge, give rise to strong water feeders. Drainage problems were further exacerbated due to the drainage sough being incorrectly sited so that the workings were only intersected at c.25m depth although they extended to c.60 metres. Consequently despite the sough having been described as being "*wrought verie artificially and substancially*", significant expenses were still incurred in pumping the greater bulk of the mine's water 'make'.

The venture was continuously beset by adverse events, labour relations were bad, the miners were being harangued to strike and were themselves described as being "*worse than devils*", "*too cunninge for Serpentes*" and a "*generation of dangerous condicioned people to deale with*". Local water supplies became '*spoyled*' by the mine water discharge and the smelt mill at Calderhead (SD878280) figured in an early account of smoke pollution when it was claimed that the "*noysomenes of the smooke . . . . destroy the grouth of all herbes and seedes sowen in a garden neere adjoyninge to the same house, and also destroyeth and taketh awaie the colour and vertue bothe of grasse and corne*".

"*This bewitchinge or deludeinge myne*" was abandoned in 1635 when the commission of local gentry, working it for Charles I, Duke of Lancaster, finally admitted defeat in a report which might still be of salutary relevance today: "*Wee observe it to bee such a bewitchinge hope that yt would draw* *men of the best Judgementes that way on to desperat experimentes and many tymes great losses, and as wee heare even in Derbyshire, the least dangerous place for faleinge, many men may, of the best Mynors themselves, have suncke and myned theire estates by followinge hopes and probabilities of this nature, for in any of them there is noe certainty further than the pointe of the picke, as in other as base as cole some of us have lost much more than all this*".[20] However, the warning went unheeded, for in 1755 the mines were reopened by the Clitheroe Mining Company, followed by the Mine Adventurers' Company, and were finally abandoned in 1766 after the unsuccessful venture lost the, then, large sum, of £1653.[21]

THE LEGACY

Most seams are worked out, the only notable remaining reserves being the environmentally unfriendly, sulphur rich, Union Coal east of the Worsthorne Fault so that any significant future mining developments are unlikely. Indeed only a few men are employed working a remnant of the Union Coal in the last remaining and only recently reopened mine at Hill Top (SD888255). The sites of the larger mines are restored although upon the surrounding moorland tangible evidence remains as collapsed adits, small spoil heaps, occasional water looses, more ancient bell pits and the fine Cornish engine house in Fox Clough, Colne (SD893393).[22]

Ever present and potential hazards exist in the form of shallow workings and concealed shafts. For whilst there are numerous references to former mining activities, including historical accounts, leases, deeds, court records and estate plans, their precise locations and depths are often uncertain. Thus whilst the earliest documentation, in 1296, refers to 10 shillings (50p) and 3 pence (lp) of *carbonibus marinus* (sea coal) being respectively mined at Trawden and Cliviger, it can only be inferred that the mines were along the outcrops of the Union Coal at Beardshaw Beck (SD903388) and Arley Coal at Riddle Scout (SD892277).23 Whilst it is known that the villagers of Marsden in 1525 were fined 12d (5 p) "*for keeping coalpits open on the Kings highway, to the great danger of the people*" the locations of such shafts cannot be identified other than somewhere close to the Arley Coal outcrop along Nelson Road (SD867361).[24] Similarly in 1552 the "*pits in the Kings Highway on the Ridge*", whilst clearly sunk to the Blindstone (Low Bottom) Coal, could occur anywhere within half a mile along Ridge Road, Burnley (SD855330). Significantly it was thereabouts, during opencast mining in 1949, that over 50% of the anticipated coal tonnage was lost due to "*old works*". The locations and horizons of all abandoned coal workings and shafts are however accurately recorded since 1872 when it became a Statutory Obligation to deposit the plans with the Mining Record Office.[25]

Unfortunately, due to, the synclinal nature of the coalfield, the rich sequence of the Burnley Four Foot and overlying coals is largely coincident with the older Victorian urban area which, during the last 25 years, has been extensively redeveloped. Since reserves of these shallow coals were exhausted well before the 1872 Act mining records are scarce and, even if available, often unreliable. Therefore most redevelopments require a preliminary mining investigation often accompanied by a lengthy drilling programme. Should any shallow workings be found, and dependent upon their sub-surface depths, relationship to rockhead (the drift/solid interface) and working heights (not always coincident with the seam thickness), remedial measures involving grout injection or reinforced foundations may be necessary. The additional costs of such works can act as a deterrent to investment so that several brownfield sites still await development.

Again since the majority of the former shafts were sunk to the shallow pre-1872 workings, and although some are shown upon the First Editions of the 1/10560 Ordnance (from 1848) and Geological (from 1869) Sheets, their precise locations are often uncertain. Indeed some are unknown until either found during the early (hopefully) stages of site development or, fortunately rarely, by their sudden collapse. At least 640 shafts and drift entrances are recorded although only 200 occur within the urban areas. Those situated upon the flanks of the basin in the rural districts are most easily found since they are usually rendered conspicuous by an associated mound of spoil or, alternatively, by a distinct hollow. Conversely those in the older parts of the towns cannot always be readily located. Their positions may be obscured beneath layers of associated colliery spoil originally used to both level the site and backfill the shaft. Invariably such shafts require treatment prior to any building works upon or adjacent to their positions. When abandoned they were either inadequately backfilled or even merely capped with stone slabs at the best or timber baulks at the worst.

Perhaps the most obvious mining legacy is that of Acid Mine Drainage (AMD) characterised by vivid orange, ochreous discharges from most water looses on the surrounding hillsides. Drainage from the sulphur-rich, pyritic Union Coal workings is particularly troublesome in that a precipitate of ferric hydroxide blankets the stream bed thereby killing most of the aquatic life. Several polluting discharges as at Nant Bridge, Cornholme (SD906270) into the aptly named Redwater Clough, and Fox Clough at Colne (SD895389), still flow over 100 years after mining ceased. A most dramatic example occurs at the confluence of Black Clough with the River Calder near Cliviger (SD874284). The Calder is clear upstream, but is immediately stained orange for over 200 metres downstream. Heavy staining and iron precipitation can be followed for almost a mile upstream along Black Clough to the discharge of the Deerplay Water Loose (SD866278). Remedial work in progress should eliminate the pollution. A borehole at Whams (SD876255) will intersect the mine waters at a low point in the former Deerplay Colliery workings. The polluted water will be pumped into a treatment plant at Bacup so that the Black Clough discharge will cease.

It would appear that, apart from a limited amount of sandstone quarrying, there is little chance of any further mineral exploitation. Nevertheless it might be apposite to conclude with some, howbeit slight, optimism concerning the coalbed methane (CBM) potential of the coalfield. For whilst the coal sequences below the Pasture, together with those above and including the Arley, were described as having a "*low coalbed methane potential*" the accompanying codicil "*unless gas content is high*" cannot at this stage be ignored.[26] Although any CBM prospect can only be small many of the deeper mine workings were exceptionally gassy. Accordingly and despite the possibility of some early Permian degasification, the CBM prospects are worthy of further consideration. In this respect any potential targets would include the Mountain Coals east of the Worsthorne Fault.

REFERENCES

1. Most Lancashire coal seams, irrespective of their being or having been worked, are usually termed: Mine. To avoid any confusion in this paper they are termed: Coal.

2. Children's Employment Commission. First Report of Commissioners for enquiring into employment and condition of children in mines and manufactories, with Reports and Evidence of Sub-Commissioners. Parliamentary Papers, (1842). [380] xv.1, [381] xvi. 1, [382] xvii. 1.

3. Broadhurst, F.M., Simpson, I.M. & Williamson, I.A. "Seam splitting" *Mining Magazine*, Vol.119 (1968), pp.455-463.

4. Broadhurst, F.M. & Simpson, I.M. "Syntectonic sedimentation, rigs, and fault reactivation in the Coal Measures of Britain" *Journal of Geology*, Vol.91 (1983), pp.330-337.

5. Earp, J., Magraw, D., Poole, E.G., Land, D.H. & Whiteman, A.J. *Geology of the Country around Clitheroe and Nelson* (HMSO, Mem. Geol. Surv. G.B., Sheet 68, 1961).

6. Kingston, A.H. *Plan concerned with inundations and influxes* (Lancashire Record Office, 1861, Plan No DDKs/27/7/80).

7. In 1945 limited quantities of pyrite were collected from the coal treatment plant at Bank Hall Colliery for the wartime production of sulphuric acid

8. Rose, J. *Marie Stopes and the Sexual Revolution* (London: Faber & Faber, 1992).

9. Weir, A.L. & Tattersall, W.H. "Power loading problems in the presence of ironstone balls" *Colliery Guardian*, Vol.214 (1967), pp.413-419 & 447-450.

10. Scott, A.C. & Rex, G. "The formation and significance of Carboniferous coal balls" *Philosophical Transactions of the Royal Society of London*, B311 (1985), pp.123-137.

11. Williamson, I.A. *Coal Mining Geology* (London: Oxford University Press, 1967)

12. Hoehne, K. "Zur Neubilding von Quartz und Kaolinit in Kohlenflozen" *Chemie der Erde*, Vol.18 (1956), pp.235-250.

13. Rippon, J.H. "The Clowne Seam, Marine Band, and overlying sediments in the Coal Measures (Westphalian B) of north Derbyshire" *Proceedings of the Yorkshire Geological Society*, Vol.45 (1984), pp.27-43.

14. Swain, J.T. *Industry before the Industrial Revolution, north-east Lancashire, c.1500-1640* (Chetham Society, 3rd Series, Vol.32, 1986).

15. Public Record Office. Duchy of Lancaster Records. DL4/76/19m4.

16. Lovat, E. *A geological section in Lancashire from the south-east boundary adjoining Yorkshire across the Ulverston Sands to the north-west boundary adjoining Cumberland* (London: Phillips, 1836).

17. Anon North Western Coalfields: Regional Survey Report (HMSO, Ministry of Fuel and Power, 1945).

18. In the adjacent Accrington coalfield, at Moorfield Colliery, 68 miners died in a gas explosion in November 1883. Here a methane outburst occurred from the roof of the Lower Mountain Coal. The worst colliery disaster in Lancashire was that at the Pretoria Pit, near Bolton, in December 1910 when a similar

methane outburst ignited and culminated in a massive explosion of coal dust with the loss of 344 men and boys.

19. Williamson, I.A. "Field meeting in the Cliviger Gorge, near Burnley, Lancashire: Lancashire Group, June 25th 1994" Proceedings of the Geologists' Association, Vol.106 (1995), pp.309-312.

20. France, R.S. *The Thieveley Lead Mines* (Lancashire and Cheshire Record Society, Vol.102, 1951).

21. Kerr, J. "On lead mining in the districts of Stansfield, Holmes Chapel, Rossendale & Great Hambledon, N.W. Yorkshire and N.E. Lancashire" *Transactions of the Manchester Geological Society*, Vol.13 (1875), pp.344-360.

22. Williamson, I.A. & Clarkson, R. "Field Meeting in the Pendle Coalfield, northeast Lancashire: Lancashire Group, June 17th 1995" *Proceedings of the Geologists' Association*, Vol.107 (1996), pp.143-145.

23. Lyons, P.E. (ed.) "Two 'compoti' of the Lancashire and Cheshire manors of Henry de Lacy, Earl of Lincoln, XXIV and XXXIII Edward I", Chetham Society, Old Series, Vol.112 (1884).

24. Farrer, W. (ed.) *The court rolls of the Honor of Clitheroe in the county of Lancaster, Vol.2* (London: Ballantine, 1912).

25. The Coal Authority, Stanhope Bretby, Burton-on -Trent, Staffs., are now responsible, on behalf of the Health and Safety Executive, for the custody of all Abandonment Plans. These are available, for examination by interested persons.

26. Glover, B.W., Holloway, S. & Young, S.R. *UK Coalbed Methane Resources* (British Geological Survey, Technical Report, 1993).

APPENDIX

COAL SEAM NOMENCLATURE: BURNLEY AREA

First recorded use, within Burnley area, indicated by date with author reference when known. (Where usage is very restricted the actual locality is stated).

Principal name		**Synonyms**
Doghole	(Diggle, 1848)	
Charley	(Hull, 1875)	
Kershaw	(Hull, 1861)	
Shell Bed	(Hull, 1861)	Palace House Thin Bed (Earp, 1961)
		Vicarage (Hull, 1875)
Burnley Four Feet	(Hull, 1875)	Burridge (Anon, 1892)
Thick Bed	(Wild, 1864)	
Old Four Feet	(Wild, 1864)	
Palace House Low Bed	(Earp, 1961)	
Maiden	(Hull, 1861)	Old Yard Bed (Wild, 1864)
Lower Yard	(Hull, 1861)	Five Feet (Hull, 1861)
Clifton Blindstone	(Earp, 1964)	Arley Yard (Habergham Colliery Ab. Plan 12613, 1939)
		Blindstone (Wild, 1864)
		Low Bottom (Wild, 1864)
		California (Ightenhill, Wild, 1864)
		Four Feet (at Padiham, Hull, 1875)
		Whittlefield (at Whittlefield, Earp, 1961)
		Toe Rag (at Habergham, Earp, 1961)

Inferior Cannel	(Earp, 1961)	Cannel (Wild, 1864)
Padiham Thick	(Earp, 1964)	Eleven Feet Coal (Hull, 1875) Olive (Ab. Plan NW1146 c.1840)
Fulledge Thin	(Hull, 1875)	California (at Ightenhill, Wild, 1864) Habergham Blindstone (Earp, 1964) Thin Bed (Wild, 1864) Yard at Gawthorpe (Hull, 1875) and Towneley (Pickup, 1871)
King	(Ab. Plan 7, 1873)	Bing (Hull, 1875) Bottom or 200 Yard Bed (Fulledge, Dickinson, 1864) Great Mine (Hull, 1861) Six Feet (Gawthorpe, Hull, 1875)
Lady	(Wright, 1927)	Slaty (Wild, 1864)
China	(Hull, 1861)	Habergham China or Cliviger Two Feet (Wild, 1864)
Crackers	(Pickup, 1871)	Crackler Bed (Dickinson, 1864)
Dandy	(Hull, 1861)	Cally (at Cliviger, Hull, 1864) California (Ab. Plan 2656, 1891) Upper Arley (Bank Hall Colliery Ab. Plan 11646, 1935)
Arley	(Hull, 1861)	Cliviger Four Feet or Marsden Four Feet (Hull, 1864) Habergham Mine (Binney, 1860) Bradgethey Coal (Lovat, 1836) Fulledge Main (Hull, 1861)
Pasture	(Wild, 1892)	Horse Pasture (Dickinson, 1864) Black Clay Coal (Hull, 1875)
Cemetery	(Wright, 1927)	
Cannel	(Dickinson, 1864)	Foot Coal (Hull, 1875) Wheatley (Ab Plan 12086/1, 1927)
Upper Mountain	(Hull, 1875)	Forty Yards (Hull, 1875), Spa Clough Top Bed (Wild, 1864) Doctor (Lovat, 1836) Towneley Black Bed (Dickinson, 1864) Thin (Cliviger, Ab Plan 11106, 1933) Half Yard (Hull, 1875)
Inch Mine	(Wright, 1927)	
Union Mine	(Wright, 1927)†	Also called Bullion, Lower Mountain (including synonyms), see below.
Upper Foot	(Dickinson, 1864)	Bullion (Binney, 1860)
Lower Mountain	(Hull, 1875)	Gannister (Binney, 1841) Rabbit (Hall, 1836) Mountain (Hall, 1836) Rearing (Whitaker, 1806) Peacock (Deerplay, Anon, 1931)
Lower Foot	(Hull, 1875)	
Bassy	(Wright, 1927)	Salts (Binney, 1860)
Six Inch	(Wright, 1927)	

† The Union Coal is formed by the coalescence of the Upper Foot and the underlying Lower Mountain Coal

REFERENCES TO APPENDIX

Anon "The Burnley Coalfield" *Colliery Guardian*,Vol.64 (1892.), p.551.

Anon D.S.I.R. Fuel Research Survey of National Coal Resources, No 19 (1931).

Binney, E.W. "Observations on the Lancashire and Cheshire Coal field" *Transactions of the Manchester Geological Society*, Vol.1 (1841), pp.67-79.

Binney, E.W. "Excursion to Burnley" *Transactions of the Manchester Geological Society*, Vol.2 (1860), pp.49-52.

Dickinson, J. "On the coal strata of Lancashire" *Transactions of the Manchester Geological Society*, Vol.4 (1864), pp.155-169.

Diggle, J. Evidence as to coal got from the Gawthorpe Estate, 1848. Lancashire Record Office, DDKS 27/5/14a.

Earp, J.R. et. al. *Geology of the country around Clitheroe and Nelson* - Sheet 68 (H.M.S.O., Mems Geological Survey, 1961).

Hall, E . *Introduction to the Mineral and Geological map of the coalfield of Lancashire* (Manchester, 1836).

Hull, E. *The coalfields of Great Britain* (London: Stanford, 1861).

Hull, E. *Geology of the Burnley Coalfield* (H.M.S.O., Mems Geological Survey, 1875).

Lovat, E. *A geological section in Lancashire* (London: Phillips. 1836).

Pickup, P. 1871 Section of strata of the Engine Shaft at Towneley Colliery, Lancs. Record Office DDX/502.

Whitaker, T.D. *An History of the original Parish of Whalley* (London: Routledge, 1806) 2nd.ed.

Wild, G. "On the Fulledge Section of the Burnley Coalfield" *Transactions of the Manchester Geological Society*, Vol.4 (1864), pp.l79-194.

Wild, G. "The Lower Coal Measures of Lancashire" *Transactions of the Manchester Geological Society*, Vol.21 (1892), pp.364-399.

Wright, W.B. *The geo1ogy of the Rossendale Anticline* - Sheet 76 (H.M.S.O., Memoirs Geological Survey, 1927).

Paper submitted – March 15th, 1999:

I.A. Williamson,
8 Gale Howe Park,
AMBLESIDE
Cumbria
LA22 0BW