BRITISH MINING No.80

MEMOIRS
2006

✡ ✡ ✡ ✡ ✡

ISSN 0308-2199

CONTENTS

FURTHER ASPECTS OF OLD FLOCKTON COLLIERIES, NEAR WAKEFIELD

By John Goodchild

INTRODUCTION

This paper reports additional information which has come to light since the author's article on the Old Flockton collieries 1772-18931. The colliery was a typical middling-sized late Georgian/Victorian, Yorkshire undertaking, about which much detail is known and much of whose infrastructure still survives on the ground today. Some of the information here is that as seen by an industrial spy of 1802.

A detailed picture of the colliery's equipment is provided by detailed inventories, the particulars of auction sales, photographs and surviving remains at the two complexes of Old Flockton at Lane End (NG 255 149) and Emroyd (NG 262 178) near Wakefield. Both worked until 1893 and were maintained in working order until 1895.

COAL PRODUCTION

The seams available were:

Seam	Depth from surface (yards)		Average Thickness (inches)
	Lane End	Emroyd	
Joan Coal	1420	Not present	12 (best), 12 (inferior)
Flockton Thick	42	At surface	10 (tops), 15½ (spavin), 14 bottoms
Flockton Thin	62	20	22 (best)
Old Hards (or Park Gate)	70	61	5½ (tops inferior), 19-20 (best)
Green Lane (or Emroyd Silkstones)	120	80	5 (bearing muck)
New Hards (or Cromwell)	140	104	23 (best), 14 (bind), 5 (lime coal)
Wheatley Lime	160	129	32 (good coal)
Blocking Bed	183	157	16 (best), 15 (fireclay)
Low Moor Black Bed	Not tested	299	28-30

In 1893, the following acreages remained unworked and were described as ‘fairly available’.

Seam	Fairly Available (acres)	Coal type
Flockton Thick	79	Very best house coal, soft brown ashes
Old Hards (or Park Gate)	500	Very best house coal, hard brown ashes
Green Lane (or Emroyd Silkstones)	300	2nd quality gas coal or soft engine coal, light brown ashes
New Hards	300	Best quality gas coal, very hard, free from sulphur, cokes well, white ashes
Wheatley Lime	200	Good but soft engine coal, much liked at Horbury mills, grey ashes
Blocking Bed	400	Good house coal, soft brown ashes
	Unworked (acres)	Thickness (inches)
Beeston Bed	2,000	30
Low Moor Bed	2,000	30
Low Moor Better Bed	2,000	30

In all, some 3,784,400 tons remained to be worked.

Output for the year 1892 was:

Colliery	Seam	Output (tons)
Lane End	New Hards Best	23,072
	New Hards Common	3,337
	Old Hards Best	12,063
	Old Hards Common	2,375
Emroyd	Wheatley Lime	14,216
	Green Lane	13,463
	Blocking Bed	7,151
	Old Hards Best	1,989
	Old Hards Common	563
	Total	78,229

In 1892, the coal and wayleave leases were:

Lessor	Minimum coal rent (£)	Wayleave rent (£)	Lease commenced	Surface acreage (acres)
Mrs Stansfeld and executors of Mrs Briggs	90	30	Dec 1874	170
Sir George Armytage, Bt.	500, 66 for land	40	Sep 1873	1,000
W.B. Beaumont, esq.	150	0	Jul 1889	130
George Lane Fox, esq.	0	100	Yearly for tramway & staith	
Lord Savile	0	20	Yearly for tramway & staith	
Earl of Wharncliffe	150	30		
Lancashire & Yorkshire Railway Co.	0 for sidings	0		

LANE END COLLIERY

In 1894, Lane End was pumped by a vertical condensing engine with a 48 inch diameter cylinder, 5 foot 6inch stroke and having a total spear lift of 80 fathoms (480 feet), using 14 buckets. This was housed in a stone building without a roof having dimensions of 26 x 21 x 40 feet high. The old pumping engine was powered by two 6 x 26 foot, egg-ended boilers at surface, working at 10 psig and a 7 foot 6 inch x 27 foot Lancashire boiler. The Old Hards Seam was the lowest worked; a 10½ inch bucket at 6 feet stroke worked at 5 strokes/minute in winter and 3 strokes/minute in the drier summer, lifting water to a lodge (reservoir) at the Flockton Thick Seam level. Water was then lifted by a 10 inch bucket to the surface at the rate of 90 gallons/minute (after allowing 10% loss for slippage). The old water level at Flockton Thick Seam was in a poor condition and unable to take all the water in winter, when it overflowed and was in part conveyed by a ring dam down to the Old Hards Seam while other water fell to the shaft bottom where a Cameron pump with two 20 inch cylinders and two 9 inch rams worked at 25 strokes/minute. This replaced what had once been the lowest stage worked by the main pumping engine. The Cameron pump was powered by two egg-ended boilers at the New Hards pit bottom and pumped 90 gallons/minute (also allowing 10% for slip). The boilers also powered a small Tangye pump and 'a heavy chain haulage working the dip side coal'. There was also a 6 x 19 foot air receiver working at 40 psig, presumably supplying air for ventilation and at one time for coal cutters. At Lane End in 1895, there was said to be *'a coal cutting machine (out of use)'* which was driven by a 20 inch diameter engine with a 40 inch stroke and having a 20 inch air cylinder with a 40 inch stroke.

There were three shafts at Lane End, all extending down to the New Hards, these were:

A YORKSHIRE COLLIERY AT WORK: THE NORTH GAWBER AND WOOLLEY COLLIERIES, 1896 TO 1915

by John Goodchild

Colliery company minute books relating to the West Riding coalfields are rare survivals and of the hardly more than a handful of sets which the writer has studied, few record much detail. Some minute books indeed suggest that many matters relating to colliery management were not, even if discussed, decided upon by the board, leaving even major decisions, which decided the colliery's development, to officials and employees. In some instances, there was a numerical preponderance of directors who were not practical coal mining men but rather financiers and or mere representatives of shareholders.

However, this was not the situation in the directorate of the large colliery owning firm of Fountain & Burnley Ltd, whose first minute book survives for the period 1896 to 1915. In this instance, a wide range of day-to-day matters were considered and decided upon by directors who are identifiable as practically experienced men and their minute book is in consequence both interesting and useful to the historian. It mirrors a variety of the company's concerns, including not only coal extraction, processing, transport and reserves but also aspects of policy and its implementation in regard to coal markets, the workforce and its wages, salaries and conditions, coal markets, machinery renewal and improvement, by-products (coke and brick making), colliery finance and dividends and, to a degree, the internal relationships of the whole enterprise.

The new firm of Fountain & Burnley Ltd came into being in 1896, under the terms of an agreement dated in the April of that year. The situation was somewhat complicated and the decision to turn a partnership over to a private limited liability concern was apparently based upon the inability of members of the Fountain and Burnley families to find any other way out of their legal and financial difficulties.

Members of the Fountain family (all deceased in 1896 except for Joseph Fountain) and the deceased G.J. Burnley, had owned North Gawber Colliery. This was taken on a coal lease from 1853 and its erstwhile sister Darton Hall Colliery from 1879. Burnley had managed these collieries and the older Willow Bank for Thorp's Gawber Hall Collieries until Darton Hall was sold. Willow Bank closed probably in 1879 and North Gawber in 1880, temporarily as it turned out. North Gawber was reopened by Fountain & Burnley in 1882 and by early 1894 it was owned by Joseph Fountain and Burnley's widow.

Woolley Colliery was opened under a coal lease of 1853 too. It had been owned since 1867 by the Woolley Coal Co. Ltd and in 1873 sold to a new company, operating under the same name. A major partner was George Pearson, an erstwhile successful railway-building contractor who was also a partner in West Riding Colliery at Altofts (as Pope & Pearson), from 1863 in the new Denaby Main Colliery and by 1866 in Darfield Main Colliery-all were major adventures financially.

These were large collieries, as the following figures of the period under consideration demonstrate:

Year	Total Employees	North Gawber			Woolley		
		Above	Below	Seam Worked	Above	Below	Seam Worked
1897	1482	582	123	Ba	442	128	Ba.
		180	27	Be			
1901	1482	474	144	Ba	579	136	Ba.
		123	26	Be			
1903	1517	475	150	Ba	555	148	Ba.
		151	38	Be			
1911	1899	662	178	Ba	641	176	Ba.
		155	33	Be			
		40	14	HM, P, S.			
1918	1773	527	181	Ba	361	151	Ba.
		33	6	KT	81	43	Be, W.
		294	24	HM, P, S.			
		66	6	KT			

Ba = Barnsley Seam
Be = Beamshaw Seam
HM = Haigh Moor Seam
P = Parkgate Seam
S = Silkstone Seam
KT = Kent's Thick Seam
W = Winter Seam

Pearson lived at Pontefract and died at the end of 1880 at 74, describing himself in his will as a colliery proprietor and leaving some £160,000. At the time of its sale to Fountain & Burnley in 1894, the Woolley Colliery concern was the subject of a Chancery suit. When it was sold, Fountain & Burnley paid 10% of the purchase price of £23,377 and the remainder was ordered to be paid into court in January 1896. Debentures in the new Fountain & Burnley Ltd, to the value of £22,500, were issued to George Pearson's heirs. Another £16,000 of ordinary shares were taken by Charles Methley and the Yorkshire Banking Co. Ltd, who had owned all the debentures in the older Woolley Colliery and a further £14,000 were taken by the Barnsley Banking Co., as North Gawber Colliery creditors. In the event, the two banks and the ex-owners of Woolley Colliery provided a large part of the new capital; the purchase price of both collieries totalled £47,500.

The directors appointed by the shareholders of the new limited company of Fountain & Burnley were an interesting group in themselves and represented a combination of professional disciplines, which were to become usual in colliery and other manufacturing concerns later in the 20th century but which in the case of Fountain & Burnley was of quite early occurrence.

At the head of the firm, as its chairman until his death in 1904, was Joseph Fountain.

TAPPING DROWNED WORKINGS, THORNLEY AND WHEATLEY HILL COLLIERIES

By Nigel A. Chapman

Rain water naturally sinks into the ground to fill up the earth and percolates into any fissures and creates open spaces in the rock. In some areas the open spaces which were formed as a result of mining activity, became waterlogged and dangerous to future mining operations. Some years ago, I described[1] a series of workings amounting to 90 acres at Staveley Derbyshire, flooded deliberately to put out a serious fire in 1857. When in 1872 the development of the Ireland Colliery to the south and down dip of the flooded workings was undertaken it became necessary to tackle the water. This was done successfully by a huge Hathorn Davey pumping engine and new water levels driven under the flooded workings. They were also fully aware of the location of these workings, so no nasty surprises in terms of driving into the unknown awaited them.

At Pelsall Hall near Walsall Staffordshire on 14 November 1872 occurred one of the worst irruptions of water when colliers driving a heading up-dip broke into old flooded workings of which they had no knowledge. The resulting rush of water and mud drowned three colliers and entombed another nineteen. After heroic efforts to erect pumping plant to remove the water, it was to take seven days to drain the shaft sufficiently for rescue parties to get underground and find the bodies of the nineteen missing colliers. The colliery was reopened and worked until finally closed in 1890.

Many other instances can be quoted of water, often from unknown sources, drowning out mines working many different minerals, in many parts of the mining world. One of the most recent was the inundation of parts of Lofthouse Colliery near Wakefield during March 1973. In this instance a heading at shallow depth went into a large, unexpected, marshy hollow and fourteen colliers were lost.

I later[2] described some of the checkered history of the Thornley and Wheatley Hill Collieries in County Durham. These mines suffered from a water problem which commenced with an underground fire in June 1858. Near the pit bottom of the downcast shaft, a steam operated haulage engine with a boiler had been placed and worked until it set fire to the surrounding coal seam. In desperation to quell the fire, water in considerable quantities was pumped into the workings. Settling in the east headways district, the water was left causing no problems at the time. During 1861 the Harvey seam was abandoned, permitting the water to gradually fill the old workings to create a water seal of the lower workings of the colliery.

The Harvey seam was always noted for its outbursts of gas, these from time to time traveled along the drowned roadways to burst out towards the shaft. Then on 8 May 1875 the whole of the surface works of the colliery were devastated by a fire that also destroyed much of the timberwork in the shaft. With no pumping plant to keep the underground water in check, the remaining Harvey Seam workings were lost and

THE CWMYSTWYTH MINES, CEREDIGION, WALES, UK: A REVISION OF LODE GEOMETRY FROM NEW SURFACE GEOLOGICAL MAPPING

By David M.D. James

SUMMARY

The area around the mines has been remapped and several significant revisions made to the conclusions of previous work by O.T. Jones[1] and the British Geological Survey.[2,3] The resulting map is now consistent with available mine plans. The larger lodes are multi-layered dextral-oblique dip-slip shear zones within which Reidel shears may dip in opposite sense to the system as a whole. The Comet Lode is newly considered to be repeated as the Penparc Lode in the footwall of the Ystwyth Fault and to correlate with the Hen Barc Lode there; furthermore the Kingside Lode is newly correlated with the North Lode in the footwall of the Ystwyth Fault. These identifications allow a new estimate of ca 470 metres of dip-slip and ca 170 metres of dextral strike-slip on the Ystwyth Fault. The latter estimate is unexpected in regional context and possible reasons for this are discussed.

INTRODUCTION

The Cwmystwyth Mines lie in the SE portion of the Central Wales Orefield (Figure 1) and represent one of the finest areas therein for the geological study of lead and zinc mineralisation. This results from a combination of excellent surface exposure, an abundance of variably accessible subsurface exposure and the availability of contemporaneous mine plans, locally supplemented above flooded levels by modern resurvey. There is thus the opportunity to assess lode geometry and host rock structure in three dimensions to an unusual degree. Moreover, the newly-detailed repetition of parts of the lode system by the Ystwyth Fault, in combination with the steep sides of the valley, sections these lodes over a vertical elevation of ca 800 metres; over twice the extent seen anywhere else in the orefield. As noted by Hall,'*unusually for Central Wales, where any one mine almost always depends on one lode, there are a great number of lodes*'.[4] The mine area is also notable for the presence of several unusually lengthy crosscut adits, most of which have long been inaccessible. These latter, if responsibly reopened, would add considerably to knowledge. One such, Taylor's (Glynderi), has become accessible during this study. The Copper Hill portion of the mines is of great antiquity and of particular archaeological value.[5] The mines were worked primarily for lead and large reserves of zinc remain.

The objectives of this paper are to present the results from new surface geological mapping of ca 7 square kilometres around the mines made on 1:10,000 or larger (locally 1:2,500) scale using GPS as an aid to positioning. This is integrated with some important recent fieldwork underground, together with a re-evaluation of published literature and calibration with the mine plans to assess the extent and identity of the principal lode systems and the geometry of their intersection with the major Ystwyth Fault. No

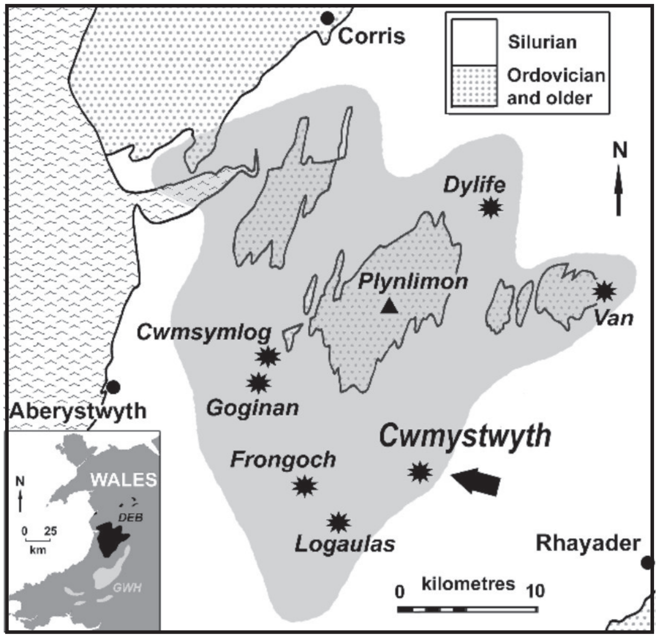

Figure 1. The location of the Cwmystwyth Mines within the northern Central Wales Orefield.

The main map shows the Cwmystwyth Mines within the orefield (shaded) in relation to other important mines and the areas of outcrop of major stratigraphic units. Inset map shows the location of the orefield (darkest shading) in Wales and the mining areas discussed in the books of D.E.B. Bick and G.W.H. Hall.[6,7]

detailed study of the mine plans is attempted.

HOST STRATA

The mines are unusual for Central Wales in that the lodes are almost exclusively developed in the basal Rhuddnant Grits of Upper Llandovery age rather than stratigraphically slightly lower in the Devil's Bridge Formation or much lower in the late Ordovician Bryn Glas Formation from which two horizons the great majority of production was derived; see Figure 2 and the regional distribution of mines shown in the compilation by the Institute of Geological Sciences.[8]

The Rhuddnant Grits comprise a succession of mudstones and fine-grained turbidite sandstones with intercalations of coarser muddy sandstones that are commonly up to about one metre thick.[9,10] Assuming that the sandstones are relatively brittle in comparison with the mudrock intercalations, there is likely to be considerably greater ductility contrast within the Grits than in the underlying Blaen Myherin Mudstones and it can be argued that this favours development of fracture poro-perm during faulting. It would also induce a degree of decollement above these mudstones during folding and this is observed. The host strata were folded and cleaved during the regional Acadian deformation of the Welsh Basin ca 396 million years ago[11] which preceeded the first phase of mineralisation, dated by lead isotope studies at ca 390 million years ago[12] and which seems likely to correlate with the 'early complex' mineralisation recognised by Mason who recognised two principal episodes of mineralisation from paragenetic studies.[13] The later episode, 'late simple', seems likely to correlate with that indicated by the lead isotopes at ca 360-330 million years ago and is broadly of Variscan age. Fold axes around Cwmystwyth trend ca 007°-015° with gentle plunges to both north and south: they are transected clockwise at about 8° by the steeply dipping regional cleavage.[10]

LODE MORPHOLOGY AND GENESIS

The lodes map as mineralised dextral-oblique dip-slip faults, commonly with dips of 55°-70° but locally approaching the vertical on Copper Hill. Fault zone width is variable, from centimetre-scale planar fracture to over ten metres of multiple lode-quality shear zones and cemented breccias interspersed with internal barely mineralised screens that

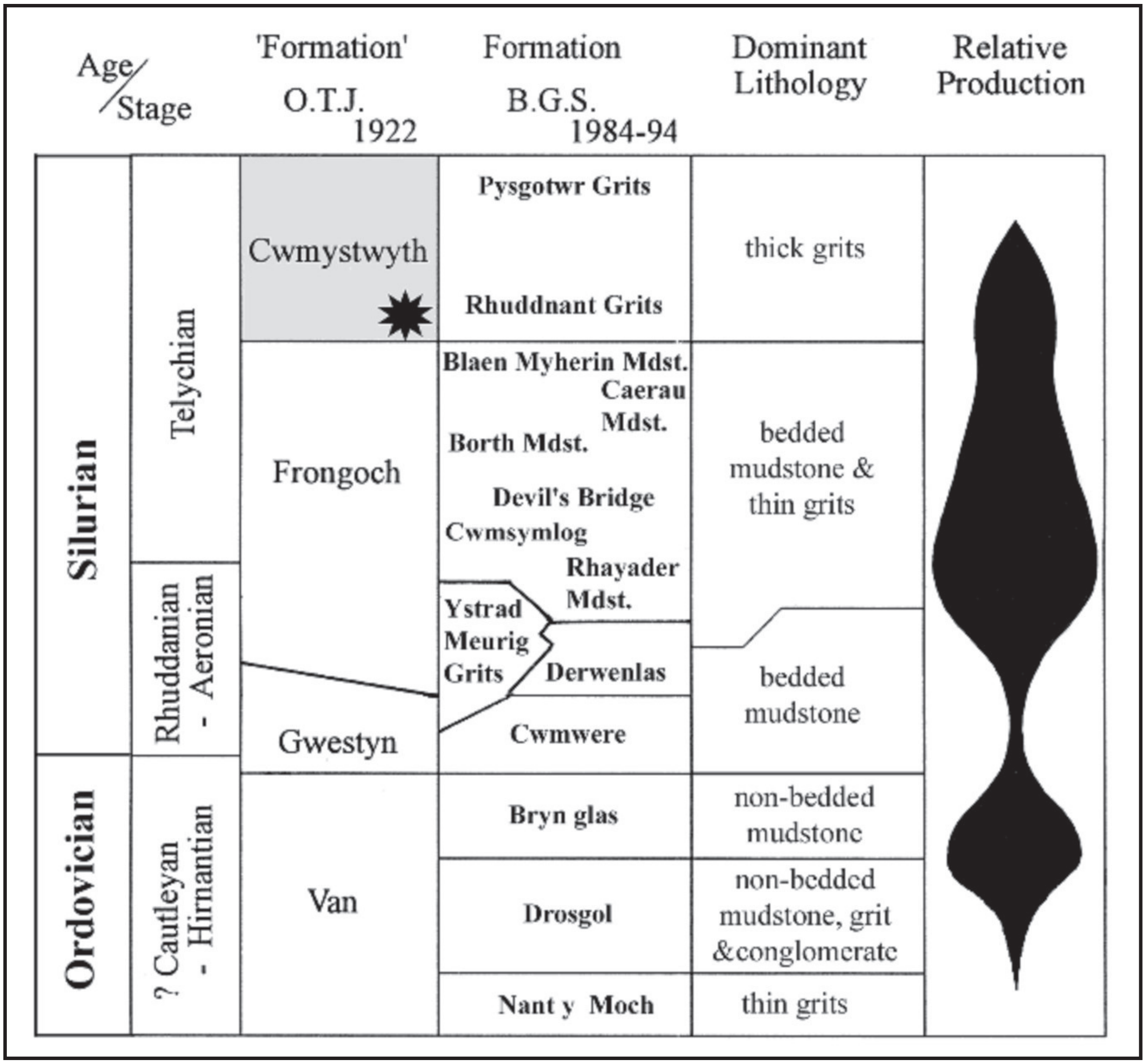

Figure 2. Host stratigraphy and relative ore-tonnage outputs (post-1845) in Cardiganshire, modified after Foster-Smith.

Foster-Smith[14] wrongly equated the Cwmystwyth 'Formation' of O.T. Jones with the Moelfre Group of W.D.V. Jones[15] which is of griestoniensis Biozone age The host strata at the Cwmystwyth mine (which are of turriculatus Biozone age) were thus too widely separated from the principal ore occurences in the Frongoch 'Group'. This created an entirely separate and unreal, concentration of production within the Pysgotwr Grits rather than a locally increased concentration just above the Frongoch Group, ie at the base of the Rhuddnant Grits at Cwmystwyth (star symbol). Very few lodes in the Drosgol Formation and below were ever explored. Note the relationship between potential hydraulic seals (thick ductile mudstones) with zones that are largely barren and that between hydraulic stores (multilayered sequences prone to more brittle deformation, small-scale folding and permeability connectivity) with zones that are highly productive

are locally seen in the Comet Lode. The lode breccias display many textural features suggestive of fracture propagation through strata with abnormally high pore fluid pressure[16,17] and their variable width and barren/mineralised zonation is a consequence of processes of asperity bifurcation and tip-line bifurcation which commonly accompany fault growth.[18] In detail there appear to be numerous minor lodes but many of these are

LODE GEOMETRY IN THE PLYNLIMON AND VAN DOMES, CENTRAL WALES, UK: THE RELATIVE IMPORTANCE OF STRIKE SWING AND RELAY LINKAGE

By David M.D. James

SUMMARY

Field and archival evidence are combined to demonstrate that many lodes in the northern portion of the Central Wales Orefield are compound structures formed by the junctions of sub-parallel precursor faults along relay faults. Locally substantial modification has been made to previous mapping of fault geometry. The faults predominantly display normal dip-slip but a minor dextral strike-slip component of movement is much more widespread than recognised previously. These results, interpreted in the context of modern work on fault growth and nucleation, modify previous views of many of the lodes as single sinuous fractures and have implications for evaluation of prospectivity. The new survey also allows correction of several mistakes/omissions in the available descriptions of mine sites.

INTRODUCTION

The first modern overview of the geometry of the mineralised faults (lodes) in the Central Wales Orefield (Figure 1) was set out by O.T. Jones[1] and updated, with minor modification and addition, by the 1:100,000 scale map[2] issued by the Institute of Geological Sciences which, with commentary[3], remains the only synthesis of the orefield as a whole. In the area of the Plynlimon and the Van Domes, subsequent mapping and revision has begun by the British Geological Survey to the W of Plynlimon.[4] All maps to date show many of the lodes as laterally extensive over 5-15 kilometres and commonly gently-moderately sinuous. Field evidence is unambiguous that any such 'swing' is an original feature and not the result of later deformation.

Two genetically different origins are possible for laterally extensive fault zones, ie those that define discrete margins of large fault-bounded blocks (Figure 2). The first is of growth of a relatively large single fracture with relatively gentle local strike swings and low-angle bifurcations dictated by the inhomogeneity of the host strata[5] and/or stress field.[6] The second is of linkage of several relatively small fractures, commonly sub-parallel and closely-spaced, to form a single larger surface.[7,8] In this case linkage is initially 'soft' as relay structures (ramp flexures or fractures) develop, commonly at appreciable angles to the generally sub-parallel precursor faults but evolves to become 'hard' when this is complete and continued deformation can then take place with a common movement vector (Figure 2c). Initial linkage is a complex function of the strain rates on the precursor faults relative to their spatial separation; this separation is conveniently; defined by their mutual overlap along strike and overstep separation normal to strike.[9]

Distinction between these origins is a function of the resolution that is possible in mapping. As exposure is generally incomplete at larger scales, the interpretation of fault

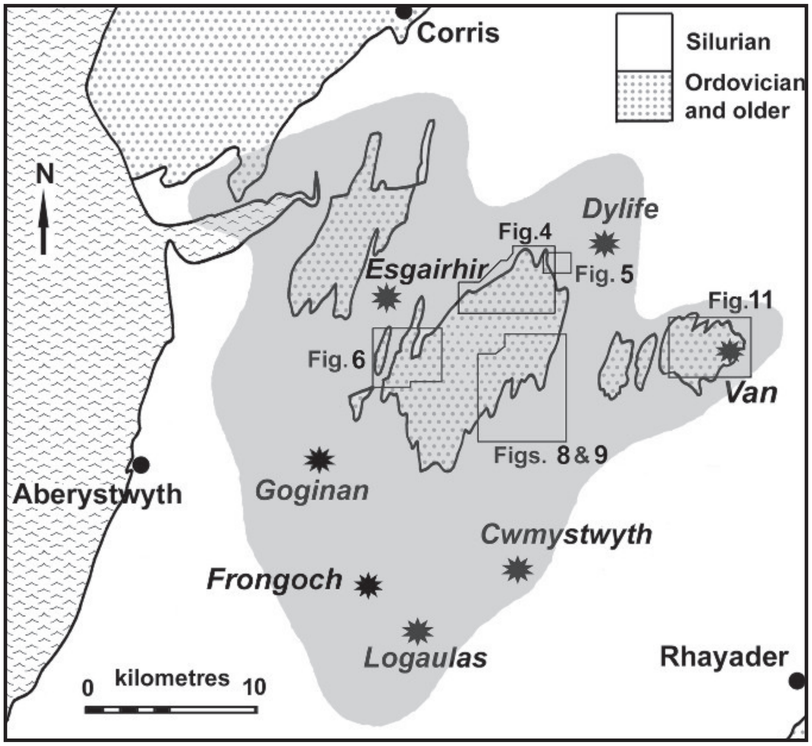

Figure 1. Location map for the northern portion of the Central Wales Orefield.

The Orefield extent is shown in grey shading together with some of the more important mines and the areas mapped in detail for this study.

orientation and continuity is subject to possible aliasing of correlations (Figures 2a and 2b). Where host-rock lithology lacks marker horizons, correlation is further hindered as an estimation of throw cannot be made even where a fault can be reliably inferred. A simple growth law for faults[10] suggests that each discrete fracture has its maximum throw at its site of nucleation (Figure 3). Such sites suffer the most episodes of slip during fault growth and thus seem likely to preferentially develop the fracture porosity and permeability (poro-perm) required to host mineralisation. For the strike swing model we might expect only one such site per simple fault; for the relay linkage model there may be several such sites along the compound fault.

A correct interpretation of lode geometry is important for two reasons. First it makes for a rational genetic explanation of occurrence and variability which should have predictive value in future exploration. Second it assists the understanding of generally incomplete archaeological evidence at mine sites by better constraining the explanation for the success or failure of the operation.

REGIONAL STRATIGRAPHY AND MINERALISATION

The host strata of the Orefield range in age from late Ordovician to early Silurian and were deposited as turbidites and mass-flows in a deep marine basin. They were folded, cleaved and suffered low-grade metamorphism during the regional Acadian deformation of the Welsh Basin ca 396 million years ago.[11] This preceeded the first phase of mineralisation now dated by lead isotope studies at ca 390 million years ago.[12] Most of the lodes in the Central Wales Orefield map as mineralised dextral-oblique normal faults, commonly with dips of 55°-70° but locally approaching the vertical. They display many textural features suggestive of fracture propagation through strata with abnormally high pore fluid pressure[13,14] and their variable width and barren/mineralised zonation is a consequence of processes of asperity bifurcation and tip-line bifurcation which typify fault growth through inhomogeneous strata.[5]

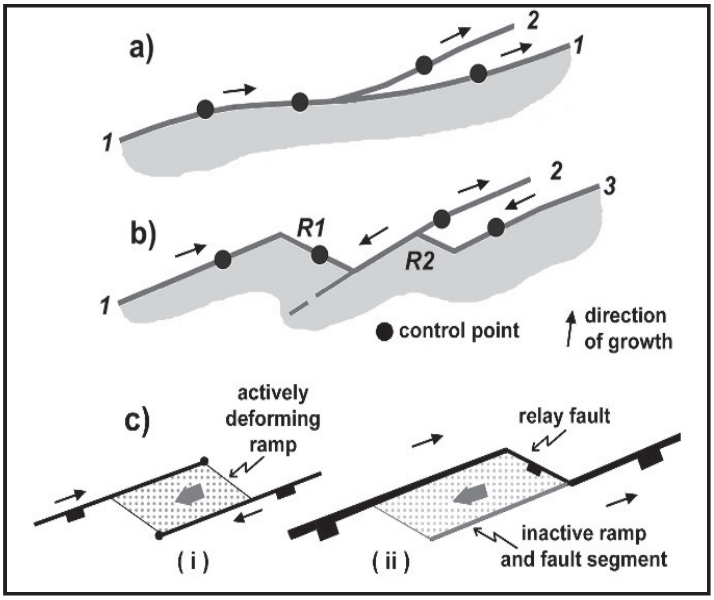

Figure 2. Strike swing/relay fault correlations if using only sparse control (solid circles) and the genesis of fault relays.

Solutions a and b both define a boundary to the same major block (grey shading) but in a it is an original feature due to one persistent fault which displays appreciable strike swing combined with a split whereas in b it arises only after hard linkage between three relatively straight impersistent faults via two relays (R1 and R2). Note that where control is sparse and orientation data at R1 is unreliable, it may be very easy to aliase the fault correlations in b and deduce the genesis shown in a.

When two subparallel faults with the same sense of slip and with opposing directions of propagation overlap, c (i), the overlapping region is deformed into a ramp with a dip (grey arrow) dependent on the lateral gradient of the throws of the faults and of the ratio between the uplift of their footwalls and the subsidence of their hanging walls. If the strain rate within the growing ramp is too large the ramp will fracture, c (ii), and the two bounding faults become linked and move together, cutting off the ramp and rendering it inactive.

Strata mapped for this study are subdivided broadly as shown on the IGS map to facilitate comparison. However the upper portion of the Ordovician of IGS is now usefully divided into the Brynglas Formation and the Drosgol Formation which lies below it. These two formations were defined by O.T. Jones[15] but later included within the Van Formation (encompassing the entire Ordovician of the study area) in his memoir.[1] The Drosgol Formation is of particular sedimentological interest and its massive sandstones have been discussed in some detail.[16] The Lower and Middle Llandovery strata of IGS comprise the Gwestyn Formation and the basal part of the Frongoch Formation as defined in the memoir. The regional stratigraphy has lately been revised and described in considerable detail and a small thickness of distinctive strata at the base of the Lower Llandovery of IGS is now known to be of latest Ordovician age.[17,18]

The contacts between the sandstones at the top of the Drosgol Formation and the largely non-bedded silty mudstone mass-flows of the Bryn glas Formation and of these in turn with the dark, commonly pyritous well-bedded mudstones which comprise most of the Lower Llandovery are generally unambiguous.

OBJECTIVES AND METHODOLOGY

The value of combining and reconciling detailed surface geological mapping at scales of 1:10,000 or larger with the subsurface archival record of mine development, notably that which commonly exists in the Mining Journal and in any mine plans, should be self-evident. A case study using this methodology for the Plynlimon mine in the area of interest for this paper has recently been completed and has yielded significant new

THE LOUISA MINE REVISITED

By Ron M. Callender

In the spring of 2006, a major Hollywood film toured the United Kingdom. The movie was *New Nation* and with brilliant photography, it told the story of 100 adventurers who set out from England in 1606 to settle in America's 17th century Virginia. On their arrival in 1607, they established a successful colony and built the town of Jamestown. The film prompted a memory and brought back my recollections of an exploration that began 25 years ago.

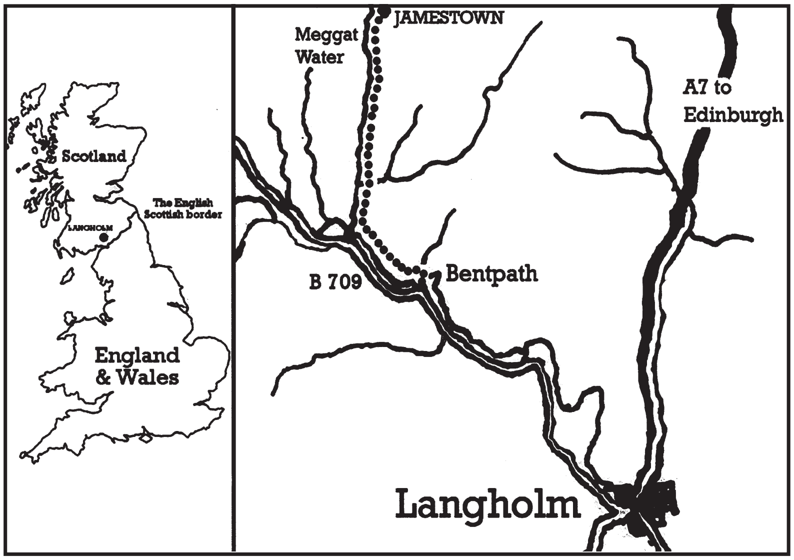

Figure 1. Langholm in Dumfriesshire is shown close to the English/Scottish border in the inset of Great Britain. Before leaving Langholm, it is important to join the B 709. After five miles, turn into the village of Bentpath and take the left-hand turn. Meggat Water is reached within one mile; three miles on a single-track road leads to Jamestown. Westerkirk is on the B 709 and less than a mile beyond the turning for Bentpath.

In 1982, I organised a family visit to another Jamestown, in Dumfriesshire, Southern Scotland. This Jamestown had come to my attention because of the adjacent Louisa Mine, which had been worked for antimony at the end of the 18th century and as far as I could determine, the mine workings had survived on a hill slope called Glenshanna, by Meggat Water. The 'township' lay about nine miles from Langholm, which is on the A7 Carlisle to Hawick road and the Meggat Water proved to be a good landmark. At Jamestown, I found it was joined by the Glenshanna Burn.

Figure 2. A sign board by the Meggat Water is a welcome sight and confirms that Glenshanna and Jamestown are located nearby.

Jamestown was not difficult to find and it would be wrong to suggest it was ever a big, thriving community. There was a cluster of houses with farm buildings and a distinctive white cottage, called 'Jamestown', which is close to three barns, one of which was

RADIOCARBON DATING OF EARLY LEAD SMELTING SITES

By Richard Smith

INTRODUCTION

Lead smelting in England and Wales in mediaeval times was carried out on carefully constructed bonfires known in the Mendips and Derbyshire as 'boles' and in the North of England as 'bales'. The open fire was usually situated in a position where there was exposure to wind of a consistent direction and strength and for this reason many were placed with an aspect ranging from south through to west, although this is by no means always the case. Examples can be found which used winds from other directions, principally from the NE or could take advantage from both quarters. Bales were superseded around 1570 in England by the introduction of new technology in the form of the ore-hearth, which was powered by bellows and somewhat resembled a blacksmith's hearth. The change from bales to ore hearths, particularly in Derbyshire, is described in detail by Kiernan[1]. The first archaeological work on bales is generally accredited to Raistrick[2] who described a site at Winterings, Swaledale, Yorkshire. Excavations have been carried out at Beeley and Totley, Derbyshire together with a reconstruction of a later bale from a contemporary description[3]. A recent excavation of a bale site at Linch Clough, Derbyshire is a further example of growing interest in this form of mediaeval lead smelting.[4]

Occurrences of bale sites in the North Pennines[5,6,7] and Swaledale[8,9] have been reported. A radiocarbon date of 1439-69 AD has been assigned by Barker to material from a site at Calver, Swaledale[8]; for many years this was the only published dating evidence for bales. Slag studies using a scanning electron microscope with an energy dispersive X-ray fluorescence detector (SEM/EDX) have been reported by Murphy[10] for sites at Fell End, Arkengarthdale, North Yorkshire, and Spout Gill, Swaledale. A more recent paper by Murphy and Baldwin[11] has described sites in Swaledale and neighbouring Wensleydale and developed a rationale for the location of bales. Brief XRF and SEM/EDX studies of the smelting residues provided the beginnings of a slag typology. Sites at Calver Hill, Swaledale have been surveyed in more detail recently by Smith and Murphy[12] and the beginnings of a slag typology developed which could be related to differences in the amount and type of residues to be found.

Many sites have been found by field walking, others by following up reports of bare patches of ground or signs of local pollution. The author has found several more in the course of looking for sites reported by others. The sites at Greenhow and Birks were found at the end of unsuccessful forays and where the author sat down to eat the remains of his lunch. Some of the sites in Swaledale and Wensleydale[11] were found by prediction on the basis that: ore would be smelted on an exposed edge if one were available, on routes downhill from mines and uphill from sources of fuel. In the vast majority of cases, bales were not found on limestone, presumably because of the difficulties arising from fissures in the rock and the generation of quicklime during burning. Even

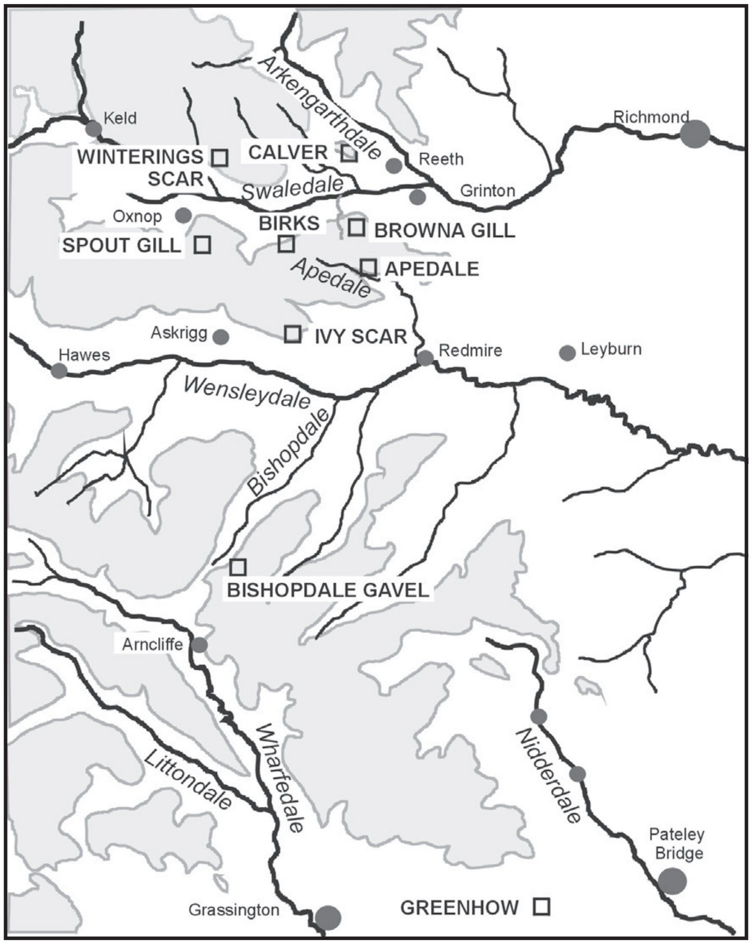

Figure 1. Location of bale sites with the exception of Calebrack, Cumbria. Sites are shown - ☐

in predominantly limestone country, bales were often found on small exposures of sandstone or where there was a heavy soil overburden.

Following the foot and mouth epidemic of 2001, which restricted access to most sites, the author together with Sam Murphy carried out a programme of work to learn more about bale smelting. This involved the compilation of a Microsoft Access database of known sites, including those reported by others. This was followed by extensive slag studies by SEM/EDX[13] which has further developed the work on slag typology, first reported in the Calver investigation[12]. Experiments have been carried out on the preparation of synthetic lead/calcium/barium/silicate slags where it has been shown that mixtures of the gangue constituents: limestone, barytes and quartz do not form a slag at temperatures up to 1,200 °C by themselves but only do so when an element, such as lead, is present which forms a low-melting silicate[13]. The same study[13] reported the determination of melting points on 20 slags, mainly from Swaledale and has led to a better understanding of the temperatures which were achieved in the fire and has given an insight into the bale structures which are necessary to achieve these temperatures. Collaborative work with Alan Powell and Rob Vernon of Bradford University has evaluated the use of geophysical techniques to examine bale sites at Grinton Smeltings and Spout Gill.

Most of the work carried out to date has been on sites in Swaledale, more recent work has also covered Nidderdale[14], Teesdale and Wensleydale. The Nidderdale study has considered the relatively scarce amounts of residues, possibly related to mineralogical composition in the area and has explored relationships of locations relative to the possible transport routes to Fountains Abbey.

Excavation and radiocarbon dating remained as two aspects of the programme of work which have not received attention and were unlikely to do so. There was a good argument for delaying excavation until more could be learned about sites, either by further examination or by non-destructive techniques. However, radiocarbon or any

FOREDALE QUARRY, HELWITH BRIDGE, A HISTORICAL AND ARCHAEOLOGICAL SURVEY

By David S. Johnson

SUMMARY

Archival research on the disused Foredale Quarry at Helwith Bridge and on other non-limestone quarries in the immediate locality, preceded a full ground survey of Foredale which was carried out in November 2004. Oral interviews with former quarry operatives were carried out in December 2004 and February 2005.

In situ remains within the quarry consist of fragmentary remnants of quarry carts, the imprints of rail sleepers on a circular rail network and on feeder tramways leading to the individual working faces, fragmentary remains of several buildings, a powder magazine, buttressing for an endless rope haulage system, remains of the drum house for the main incline leading out of the quarry to the lime kilns and working faces and spoil heaps of different phases.

The quarry and limeworks operated from 1878 to 1958.

INTRODUCTION

An extensive desktop survey was carried out to add to preliminary material on the quarry and limeworks already researched and published by this writer.[1] A detailed ground survey of surviving features within the quarry and on the site of the former limeworks was carried out before deterioration inevitably began to take its toll on the remains and because no previous survey of the quarry had been identified. A full report was compiled on completion of the field and desk-based work and deposited in appropriate archives, including the NMRS.

Foredale Quarry is unique within the Yorkshire Dales in having many features fossilised exactly as when the complex closed down in 1958. All other limestone quarries have either had their historic aspects removed by later quarrying (eg Horton, Giggleswick and Swinden), or by post-quarrying use as landfill sites (eg Craven at Langcliffe, Skibeden east of Skipton and Leyburn Shawl).

Foredale Quarry is located at Helwith Bridge some 6km north of Settle. The quarry is centred on grid reference SD 799 704 and it lies to the north-west of the site of the former limeworks which was demolished and cleared over 20 years ago. The quarry floor lies on two levels around 350m OD while the limeworks site lies at 225m OD.

GROUND SURVEY METHODOLOGY

The initial approach was to photograph, using a digital camera, all visible remains within the quarry, on the incline and at the site of the limeworks. A total of 265 digital colour images were taken, all of which were later stored onto CD, with ninety three 35mm colour slides. The entire complex was then surveyed using a Zeiss R55 Total Station to accurately plot the quarry working faces and all features within the quarry area. Minor features, such as quarry carts and buildings, were measured by tape. Specific heights were obtained with an altimeter accurate to 1m. Surveyed points were fed into Penmap 4.34B and downloaded onto hard copy form.

LOCAL QUARRYING CONTEXT

Helwith Bridge has had a long history as a quarrying community and it contains a high concentration of quarries that exploited and, in two cases, still exploit the varied geological resources of the locality.

There are four defunct quarries:

	Grid reference	Main Product
Combs	SD 800 701	blue flags
Combs Thorns	SD 801 693	blue flags
Helwith Bridge	SD 810 692	flagstones; later, crushed stone
Studfold	SD 814 701	flagstones

Two quarries are still operational:

Arcow	SD 804 703	blue flags and flagstones; later, crushed stone
Dry Rigg	SD 803 693	blue flags; later, crushed stone

Combs Quarry dates from at least the 18th century and was quoted with Arcow and Dry Rigg as one of the potential major sources of traffic for a canal to link Settle with Lancaster, proposed in 1774.[2] The prospectus extolled the *'many inexhaustible quarries of blue-flags, grit flags, excellent blue-slate and grit slate'* found at Helwith Bridge.

In 1855 Combs Quarry, then owned by Richard Clapham of Austwick Hall, was advertised to let as a source of 'blue flag' or slate.[3] Later that century it was being operated by William Ralph of Settle and then by his son Christopher, who advertised themselves in the 1880s and 1890s as 'Blue Flag Merchant' selling a wide range of vats, cisterns, tanks, headstones, tablets, urinals and chimney pieces.[4] A stone saw mill, utilising a donkey engine, stood on the level ground just west of Foredale cottages.

It has not been possible to determine exactly when Helwith Bridge quarry was first opened up but, in the 1870s, the quarry, then two small workings, was operated by Christopher Brown 'and others'[5] and, from the late 19th century, by the Ralphs. On an undated but probably mid-19th.century map the quarry appears as 'Sunny Bank Slate Quarry'.[6] The Ralphs sold the business at the time of the First World War to Henry Whittaker who, in turn, sold it on in 1922 to William Walton of Bingley. He abandoned the cutting of flagstones in the 1930s in favour of producing crushed stone, which was in huge demand for the post-war road building programme and despatched crushed stone by motor lorry to the rail sidings at Horton in Ribblesdale but sold his quarry interests here in 1938 to Albert Braithwaite of Leeds when it became The Helwith