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DELVING IN DEAN: THE DELVES - AN AREA OF UNRECORDED EARLY COAL MINING (PART THREE)

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Introduction

The *GSIA Journal for 2004* carried an article describing a project to survey and record old coal extractive workings, then unrecorded, in 'The Delves Inclosures' in the Forest of Dean. This is in the north of the Forest, west of the Northern United site and south of Brierley at SO 6315. Some 346 features were recorded**.** The location of each feature was established using hand held Global Positioning Systems (GPS). The results were plotted by computer onto a large-scale OS map by Jon Hoyle at the Gloucestershire County Council Archaeology Service. It was noted that the workings, though mostly taking the form of roughly circular pits, varied widely in depth (0.2-3.0m) and diameter (2-12m), many having spoil heaps, others without. At the bottom of two adjacent pits at the eastern end of the site, and one at the western end, the top few courses of stone lined infilled shafts were visible.

The area surveyed is shown on OS maps as 'The Delves Inclosures'. Similar workings appear elsewhere in the Forest, some but not all being labelled 'The Delves'. The team adopted the term 'delve' to describe an approximately circular pit, with or without an associated spoil heap, 'delves' collectively. Other features were shallow, irregular depressions or subsidences, and these were dubbed 'depressions'. Similar circular workings elsewhere in the UK are normally described as 'bell pits', Figure 1. Dating is normally given as either 'early' or 'pre-seventeenth century'. However the team was not convinced that the term 'bell pit' adequately described all the features observed, an impression reinforced by Brian Johns' subsequent work at the site of the above mentioned two stone-lined shafts. Brian Johns is a Free Miner and a dowser, who has discovered buried archaeological sites since proved by excavation, and underground mineral working features, later proved by records. His work here, Figure 2, is interpreted as identifying underground roadways associated with two separate unconnected areas of coal extraction, one including A7 and A11, the two stone lined shafts. The use of dowsing in connection with mineral extraction is recorded as early as 1556 in De Re Metallica (1)**.**

Having written up the survey results, the team decided on a follow-up project to investigate, as far as possible, the nature of these workings; if not bell pits, what were they? - and to attempt to date them more precisely than 'pre-seventeenth century'.

Further Investigation

The terrain of The Delves Inclosures is difficult to survey, as it includes dense mainly evergreen woodland, sloping steeply in places, with thick undergrowth. Access is only possible in winter and in early spring when the ground may be very wet. Attention was directed to the Oaken Hill area (SO 6308)**,** on the south side of the Parkend-Yorkley road at the junction with the minor road from Moseley Green. This is a mainly level site, with fairly open deciduous,

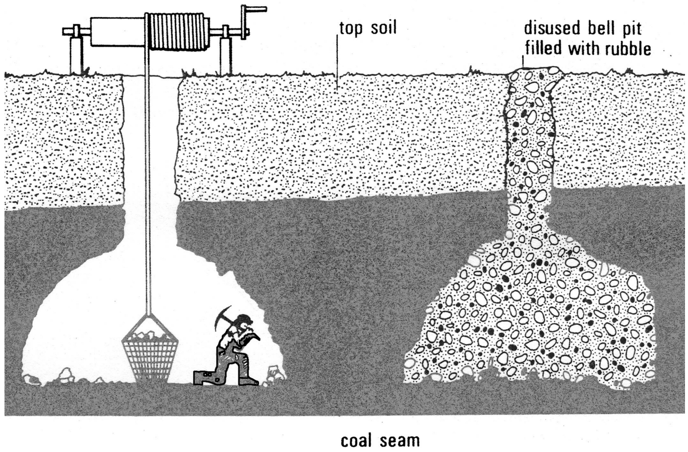
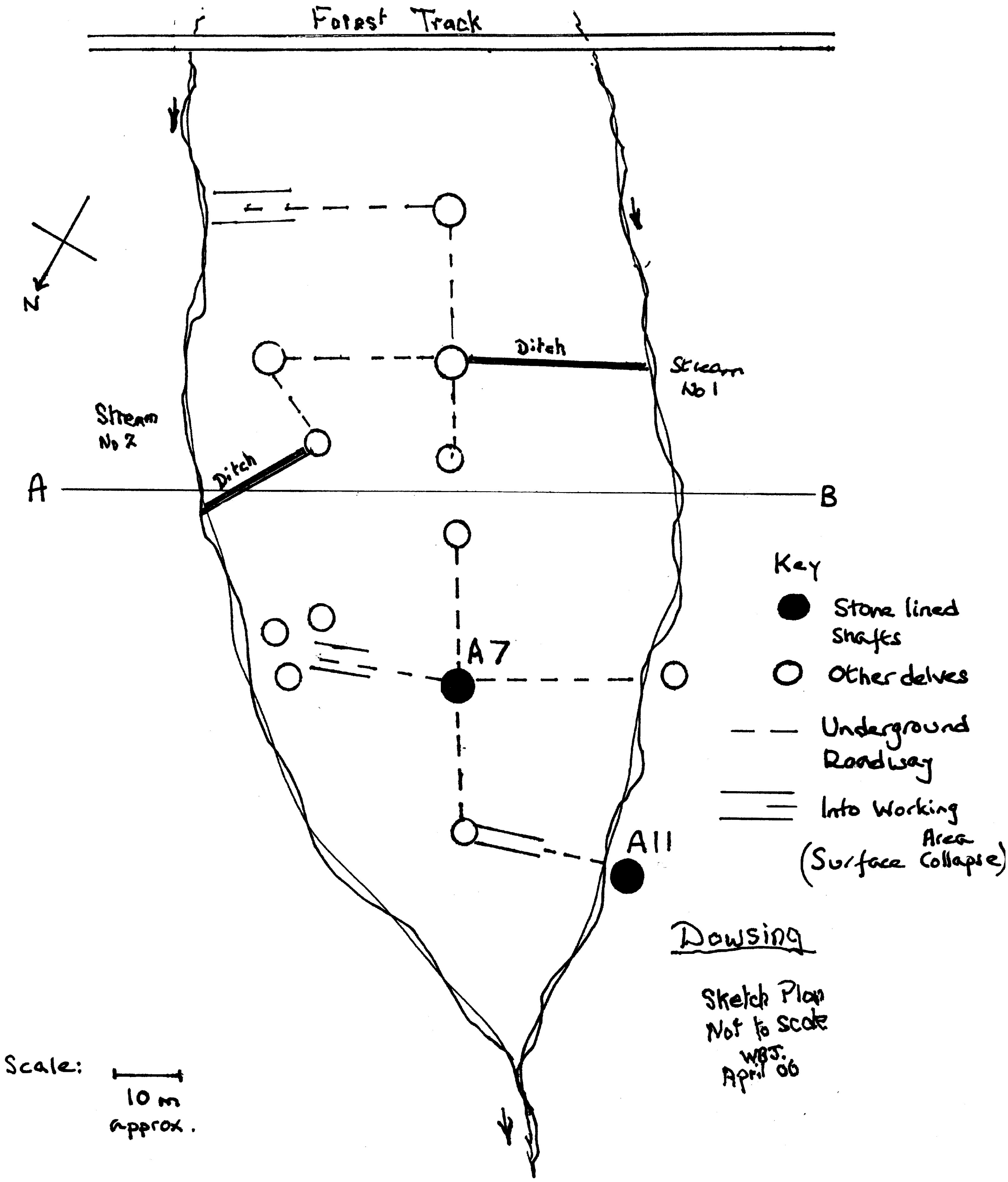


Figure 1. Schematic representation of a Bell Pit



The workings to the north and south of line AB are not connected

Figure 2 Dowsing in The Delves Inclosures, Brierley

mainly oak, woodland and less dense undergrowth than The Delves Inclosures. Moreover the workings, which at The Delves show a bewildering variety of form and size, here fall into three distinct groups, Figure 3. Group A has a number of large and small delves mingled with non-circular depressions which seem to be subsidences, Group B has larger, more widely spaced delves while Group C contains a large number of mainly small closely spaced delves. A preliminary survey was made in March-April 2006, recording and plotting the main features.

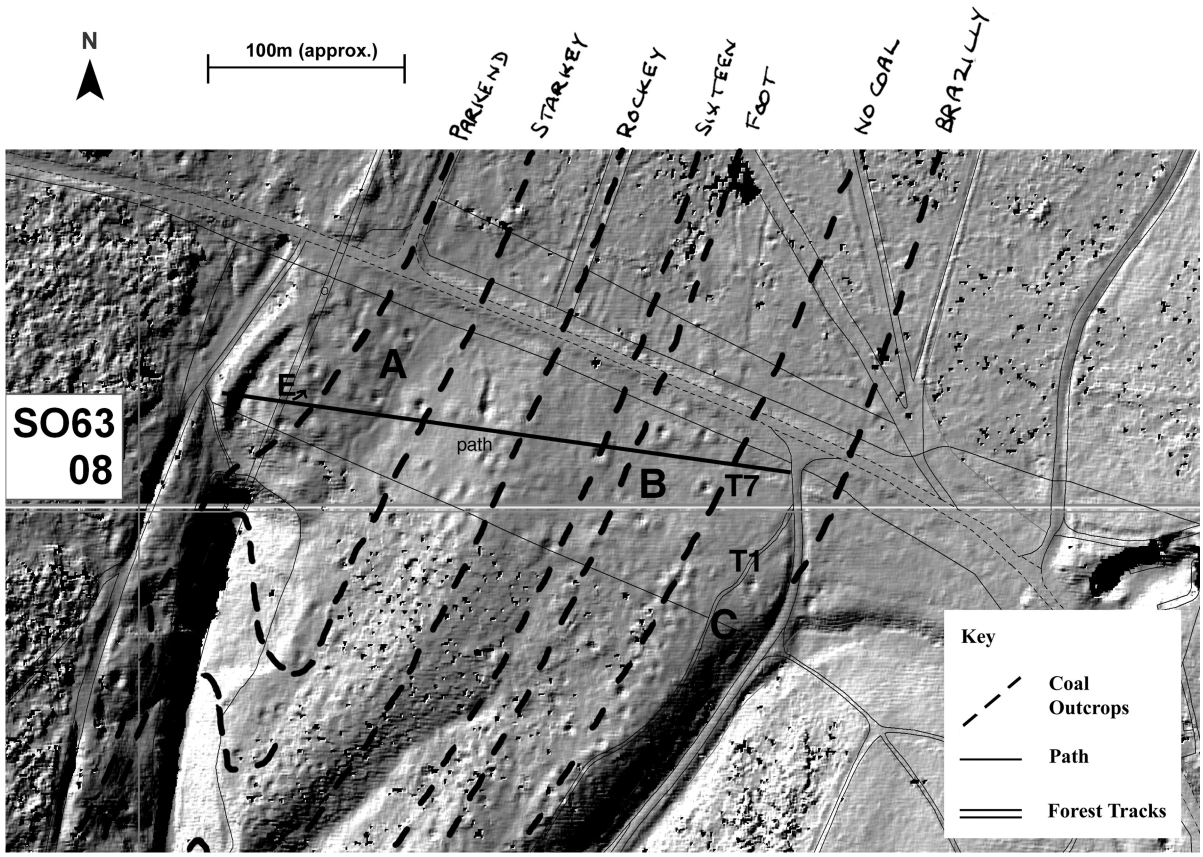


Figure 3 Lidar Image of Oaken Hill with coal outcrops based on the 6 inch Geological Survey map SO60NW © Forestry Commission and Gloucestershire County Council

Lidar

In January 2007 the results of a Lidar survey of Oaken Hill, being part of a survey of the whole Forest commissioned by the Gloucestershire Archaeology Service and partners including the Forestry Commission, were kindly made available by the Service, with a request that the team compare the Lidar image with features visible on the ground, which was done in the course of a visual survey carried out in March 2007.

Lidar (Light Detection and Ranging), (2) is a survey technique which involves overflying the target area in a fixed-wing aircraft. The ground below is scanned with multiple laser pulses (typically 20-50,000 per second) which are reflected back to the aircraft. Pulses reflected from the ground will take longer to return than those reflected from taller objects such as tree-tops; and in subsequent processing only the pulses with the longest time-delay are used to produce an image of the surface at ground level. In theory the technique should be ideal for use over forested areas where aerial photography is ineffective.

The GSIA team found that the Lidar images matched well with the features observed on the ground in areas covered by mature deciduous trees. Under mature conifers, the Lidar image is less well-defined but it is still possible to see that there are features of archaeological interest. However Lidar cannot penetrate dense ground-level vegetation or densely planted young trees, which is unfortunate since these areas are also impenetrable on foot. Buildings are fairly well depicted. Despite these reservations, Lidar is an extremely useful tool for surveying forested areas, capable of producing excellent images of extended sites which would otherwise be very laborious and time-consuming to survey. Notably, computer processing can produce images

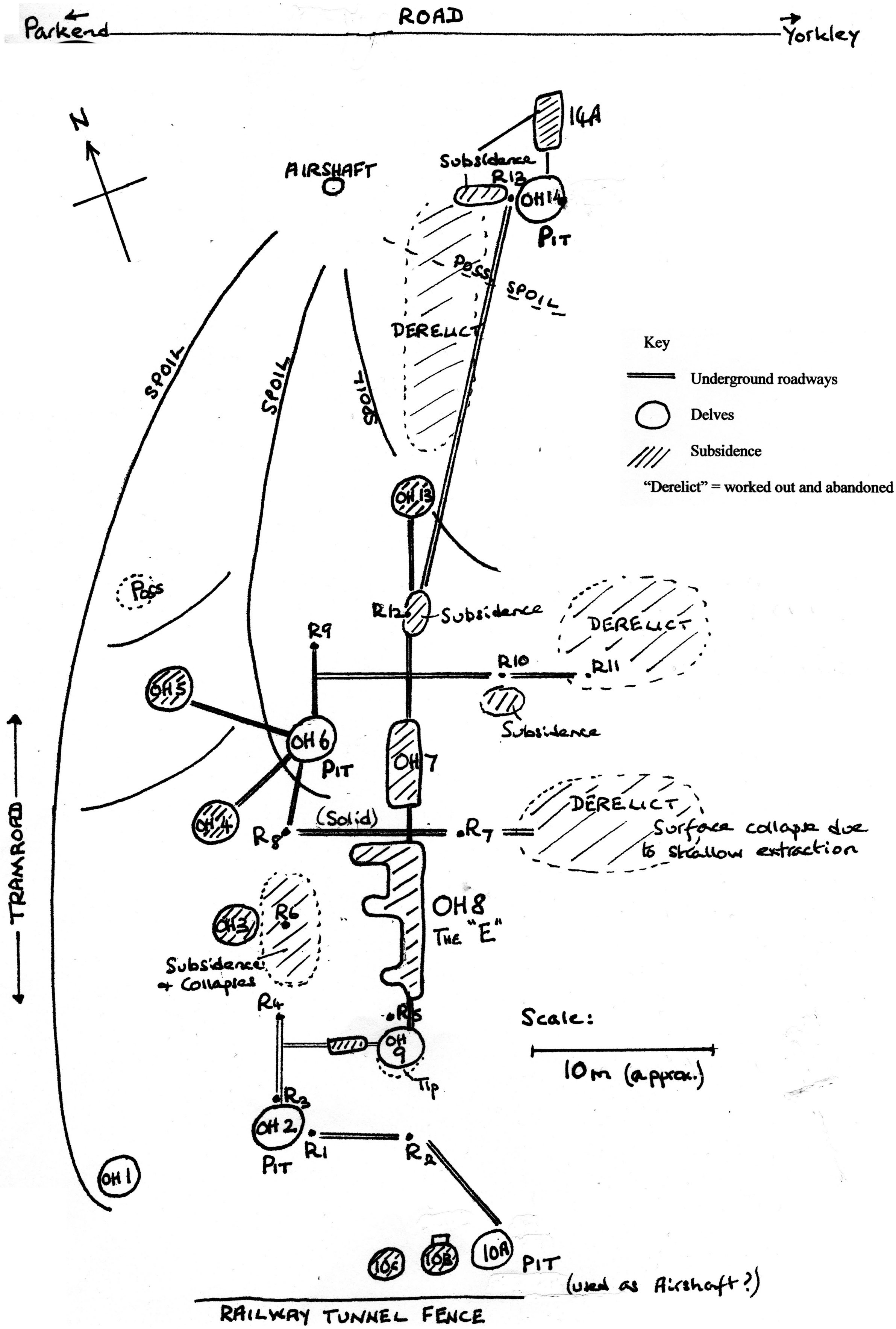


Figure 4 Dowsing at Oaken Hill

that are displayed as though illuminated from the north east or the north west. These hill shaded images, a very useful aid to interpretation, were produced by Forest Research.

Oaken Hill

The accuracy of Lidar being established and its utility recognised, the Oaken Hill plots were used as the basis for further research, which was in three phases.

Phase 1. Dowsing. Brian Johns agreed to investigate, with the team recording, a section of Group A, chosen because of the complexity of its features. The results are shown in Figure 4. The dowsing again indicated the presence of below surface ways linking certain delves, which may be ventilation passages, or roads for conveyance of coal to a shaft bottom for haulage to the surface. These are associated with areas of coal extraction, probably pillar and stall, as indicated by dowsing. These latter often show on the surface as irregular, uneven depressions, but an exception is the distinctive feature 'E', so-called because of its shape. These workings are in the Parkend seam, here 3 feet thick. On workings generally less than 50m below the surface, subsidence is unlikely to show on the surface if the depth of a seam is greater than 10 times its thickness (3). It follows therefore that the collapsed seam is unlikely to be more than 30 feet down. The work in Phase 2 below, confirmed that the 'E' is indeed about 30 feet down. Brian Johns has pointed out that earlier, shallow workings might well have been reworked later, for more efficient mineral extraction or to access deeper seams.

Phase 2. Geology: The Coal Seams at Oaken Hill

The aim in this phase was to try to establish the depth of some of the delves and to identify which seams were being worked.

The 6in. to 1 mile Geological Survey map shows that seven coal seams have outcrops in Oaken Hill between the disused railway cutting which forms the western boundary and the stream at the eastern edge (see Figure 5). The map also gives the depths and thicknesses of these seams in the Crown Colliery shaft (now closed), 200m to the north of Oaken Hill. The terrain is fairly level and there is no reason to think that the geology under Oaken Hill is very different from that at Crown Colliery.

The Lidar image (Figure 3**)** of Oaken Hill and an aerial photograph taken in 1946 when the area was cleared for replanting (Figure 6**)** show bands of workings trending approximately NE-SW, the same orientation as the coal seams on the geological map. The lines of the outcrops from the geological map were traced, scaled up and superimposed on the Lidar image Figure 3. These lines should not be regarded as precise because the positions of most of the outcrops shown on the geological map are interpolations, except for the Brazilly and the No Coal outcrops which are shown as proven south of the Parkend-Yorkley road in Oaken Hill.

Figure 7 was constructed by scale drawing using the geological map data for Crown Colliery. The distance from the shaft to each outcrop was measured on the geological map along the line X-Y Figure 5**.** The measurement uncertainty is equivalent to about ±5m on the ground. The corresponding uncertainty in the depth is ~2m. The 19º dip angle obtained correlates with the dip data on the geological map.

Most of the seams under Oaken Hill are about 18in (0.5m) thick; on horizontal ground they would outcrop as bands about 4ft (1.25m) wide. Where the outcrops have not already been worked out, they would be covered by soil formed by erosion and decaying vegetation, rather than being exposed as on a hillside or river bank. There are exposed outcrops of the Parkend, Starkey and Rockey seams in the railway cutting.

Figure 7 shows that the seams very quickly become deep. At 10m behind the outcrop the seam is already 4m deep and a bell pit 25ft (7.5m) deep - the maximum depth that could be pumped

Key

AS Airshaft
CC site of Crown Colliery
TR Tramroad Tunnel
XY Line of section used to construct fig. 7c

Forestry tracks

Stream

Coal Seams

Pk	Parkend	3ft.
St	Starkey	14in. & 17in.
R	Rockey	20in.
Sx	Sixteen	15in.
F	Foot	13in.
NC	No Coal	22in.
Bz	Brazilly	24in.

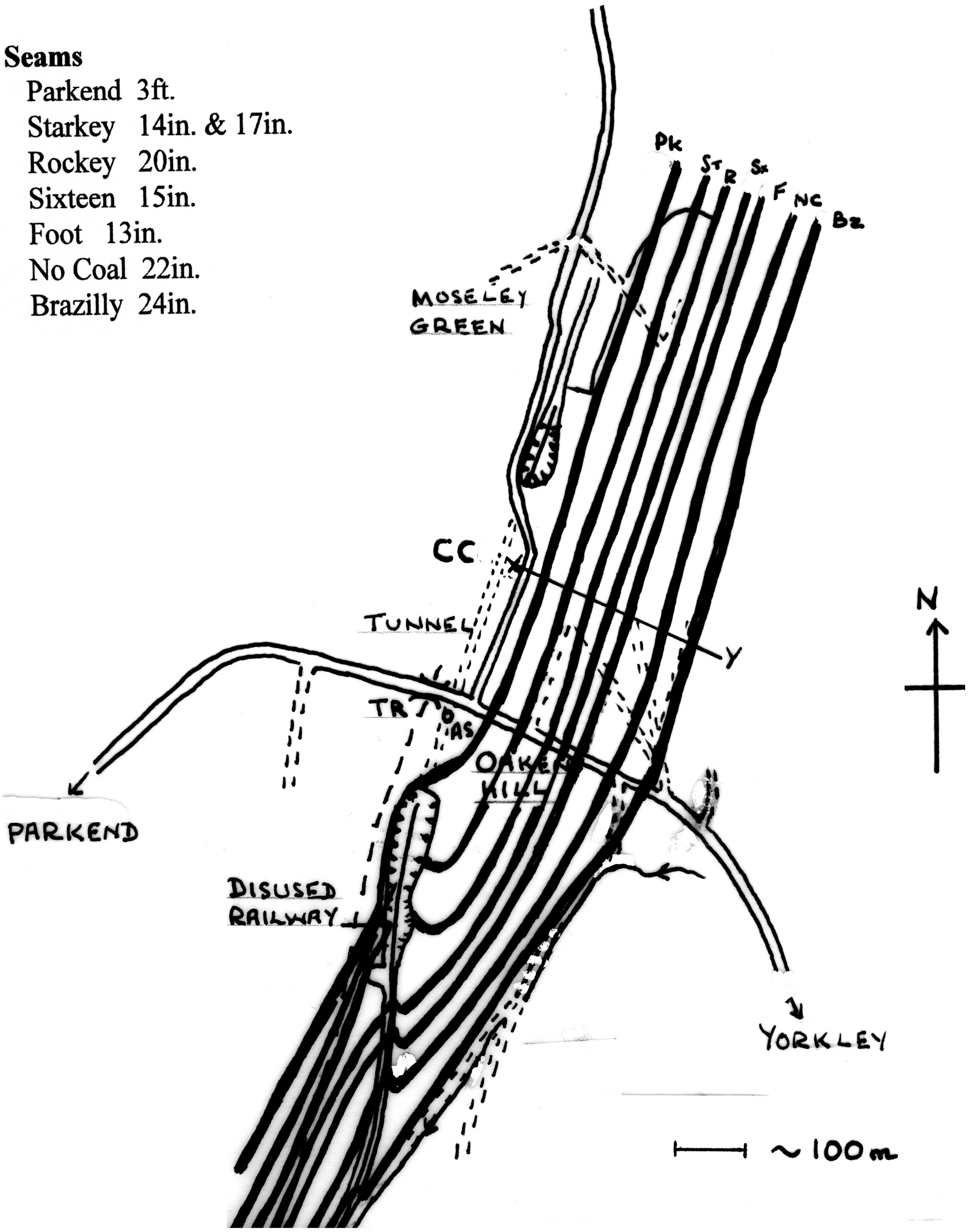


Figure 5. Sketch Map of the Coal Outcrops at Oaken Hill based on 6 inch Geological Survey sheet SO60NW (Not to scale)

Figure 6. Aerial Photograph of Oaken Hill, December 1946
Reproduced by kind permission of English Heritage (NMR) RAF Photography

using a simple lift pump - would be about 20m back from the outcrop. If the water was removed using a bucket and chain, or a rag-ball pump, or pumped in stages by a series of lift pumps, then greater depths could be reached and the pits would be further from the outcrop.

The small, closely-spaced delves of Group C (Figure3) must have been working the Brazilly seam since there are no seams below this until the Yorkley at approximately 400 feet, apart from the Nameless at 150-200ft (45-60m)which is only 2-4in (50-100mm) thick and not worked commercially. The Group C delves would be quite shallow, probably less than 4m deep. These are probably the earliest workings at Oaken Hill because the Brazilly outcrop would have been exposed on the bank of the stream.

In Group A, the position of the "E" relative to the Parkend outcrop indicates that these workings are in the Parkend seam and are about 10m deep. The Group A delves must predate the construction of the railway tunnel because some of them are partly under the spoil heaps which radiate from the air shaft.

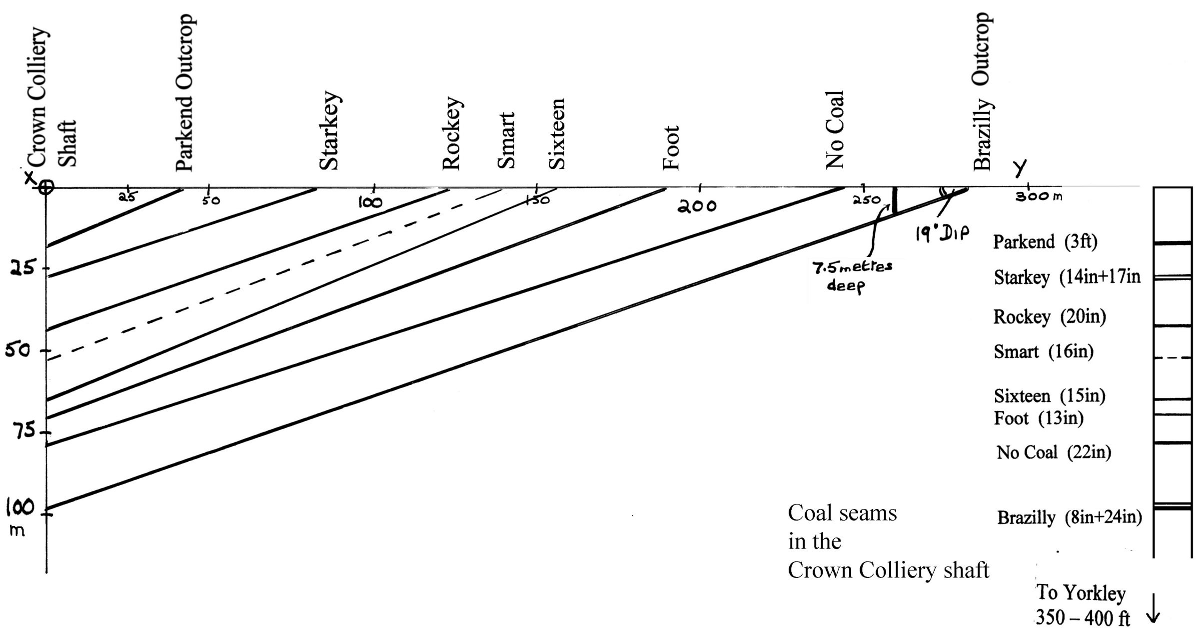


Figure 7 Section of Coal Seams near Crown Colliery along the line XY

In Group B, delve T1 (Figure 3) is about 5m deep. Delve T7 is ~ 3m above the No Coal seam and ~ 25m above the Brazilly. For comparison, approximately 1 km south-west of Oaken Hill at SO 627071, the geological map shows two pits in similar positions relative to the outcrops and their depths are given as '12ft to Brazilly' and '48ft to No Coal'. Since, except for the Brazilly and the No Coal, the positions of the outcrops in the part of Oaken Hill which the team studied are interpolations, it is not possible to be certain which seams were being worked by individual delves in Group B west of the No Coal outcrop, nor by the prominent bands of outcrop workings visible in Figure 6.

Figure 7 gives the right order of magnitude for the dip angle of the coal seams and the depths of pits, but has limitations. The data for the three seams recorded in the railway cutting at Oaken Hill show some differences from Crown Colliery in the thicknesses and depths of the strata; there are also differences of 5-10m in the distances between the outcrops along XY and at the Parkend-Yorkley Road. Nevertheless Figure 7 has proved useful for understanding the behaviour of the seams under Oaken Hill.

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Phase 3. Geophysical Investigation: Electrical Resistivity Measurements.

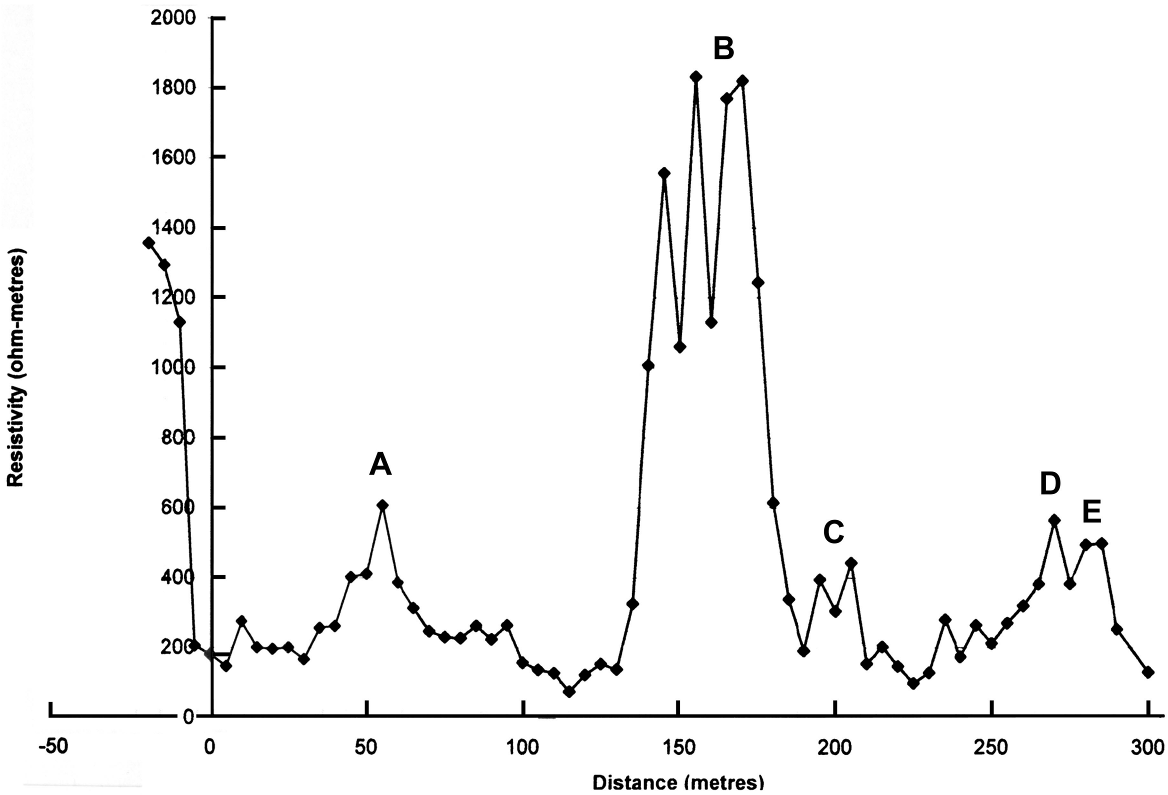
The principle of a resistivity survey is that a small current is introduced into the ground through a pair of outer electrodes and the resistance of the ground to the flow of current is deduced from the potential difference measured between a pair of inner electrodes (4). Crystalline rocks have high resistivities (500-10,000 Ωm), whilst less dense deposits would be expected to have a lower resistivity (50-1,000 Ωm). The presence of moisture in the strata reduces the resistivity. The apparent resistivity can be measured at different depths by varying the separation between the electrodes (a). The depth over which the apparent resistivity is measured is a to 1.5a.

The aims in taking resistivity readings were to see if the coal outcrops could be located and to see whether it was possible to detect underground workings.

The equipment was tested on an area of sandstone well to the east of the Brazilly outcrop by expanding the electrode separation from 1m to 9m along a N-S line and then an E-W line. The results were found to be consistent. The resistivity showed a marked change in gradient between electrode spacings of 1m and 2m which probably corresponds to the depth of the deposits above the sandstone strata.

Measurements were then taken at 5m intervals along the path which runs approximately E-W across Oaken Hill (Figure 8) to see if the outcrops could be located. An electrode spacing of 2m was used since the outcrops are probably buried under 1-2m of soil and the electrodes were placed perpendicular to the path. In the horizontal plane the outcrops will be bands about 1.25m (4ft) wide separated by about 25m of shales etc., although the No Coal-Brazilly separation would be about 50m.

The large peak B on Figure 8 correlates well in position and width to the band of ‘hard, jointy rock’ (5) between the Starkey and Rockey Seams, evident on the ground as a shallow N-S ridge. The dips in the graph could be due to damper soil conditions where bands of fireclay occur. The peaks D and E are associated with spoil heaps which radiate from the air shaft. Peak A may indicate the bands of shale between the No Coal and Foot seams. The peaks C are close to the Starkey seam. However because of the uncertainties noted in Phase 2 regarding the exact positions of the outcrops, it is not possible to match individual resistivity readings to the coal seams. The hard sandstone can be distinguished from the shales and coal seat earths but no pattern emerged which is a characteristic ‘signature’ of coal. Perhaps the 5m interval between the readings was too wide a gap to detect features ~1.25m wide.



Resistivity Readings taken at 5m intervals along the footpath which runs approximately E – W across Oaken Hill, starting from the gate on the Forest track at SO633080.
Electrode separation: 2 metres. **0 is the centre of the track.**

Figure 8. Resistivity Readings across Oaken Hill

Measurements were also taken around several delves and around the feature known as the "E" which is thought to be collapsed pillar and stall. These measurements were taken with expanding electrode separations in order to penetrate deeper into the ground to see whether underground workings could be detected. No conclusive patterns emerged from the "E", but it is now known that these workings are probably about 10m underground, much too deep to be detected by the method used.

The delves which were investigated stand alone and are surrounded by a ring of spoil containing coal fragments. The measurements around the delves were taken along four perpendicular lines at the delve, expanding the electrode separation along each line. It was hoped to determine whether the delves are just shafts, or have lateral workings around their base. The readings from all the delves showed asymmetries and irregularities, the most striking being T1 (Figure 9). T1 is a water filled delve, 5m in diameter, located about 15m behind the Brazilly outcrop and about 5m above the seam (Figure 3).

It can be seen from Figure 9 that the readings on the N and E sides of T1 are much higher than on the S and W sides. All four sets of readings show a change in gradient at an electrode spacing of 3m, corresponding to a depth of 3-4.5m. The asymmetry might indicate water filled workings on the SW side of the shaft, or voids in backfilled workings on the NE side.

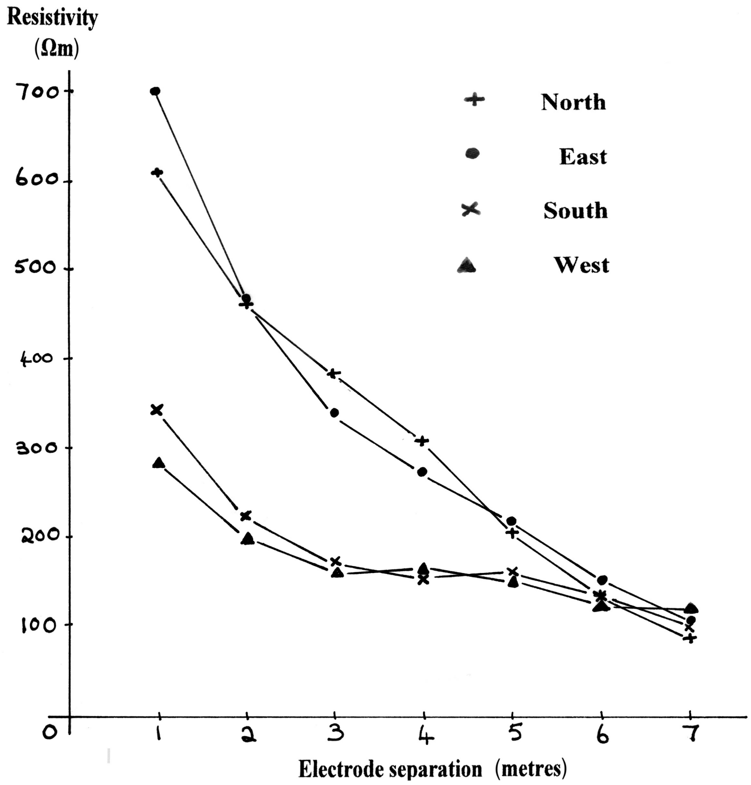


Figure 9 Resistivity Readings around T1 (a water-filled delve)

The interpretation of T1 is complicated by the presence of a waterlogged vehicle track close to the western side. It had already been noticed that soil moisture affects the readings, repeat readings after overnight rain being 15-25% lower. The last set of readings of the season, taken on sandstone at Bromley Hill, showed the effect of soil compaction on a nearby vehicle track. The resistivity was ~1300Ωm, the expected value for sandstone, whilst on the vehicle track it was only ~400 Ωm. There is also some doubt whether the current would penetrate to a depth of 3-4m in waterlogged conditions (6).

However, whilst the presence of the vehicle tracks alongside T1 might account for the low readings on the W side, it does not account for the substantial discrepancy between the N and S sides. The interpretation of the anomalies around T1 and the other delves is inconclusive, but would seem to merit further investigation.

Bell Pits To Pillar and Stall

Groups of delves positioned close to the seam outcrops, as Group C at Oaken Hill, and at Bromley Hill (below), would be the first to be worked, being the easiest. The very earliest may have been no more than shallow opencast. It seems unlikely however that the conventional bell pit form would have been used. Figure 1 shows a bell pit whose coal seam is of a thickness greater than the height of the miner working it, a circumstance impossible in the Forest, where very thin seams below unstable rock or earth formations would prohibit textbook bell pit working. Much more likely is the form of 'thin' bell pit suggested to us by Ian Standing, where the horizontal working is quite shallow, commensurate with the thinness of the seam. The low roof would be supported by 'stick and lid', a short prop supporting a wider plank.

Coal deposits underlying the Forest are saucer-shaped; the dip angles at Oaken Hill are of the order of 20°. It follows that as the workings moved progressively inwards from the outcrop, becoming ever deeper, the ratio of spoil removed to coal recovered would inevitably increase, and as the seams in question are quite thin, of the order of a foot or two, a point would soon be reached at which below surface horizontal, probably pillar and stall working would be required. Severely height-restricted working persisted well into the 19th century in the Forest. The 1842 Commission Of Enquiry Into Child Labour reported that in Dean mines, boys commonly pulled a hod of coal, weighing 1 to 1½ cwt. by means of a body harness attached to the hod by a chain. 'Where the seams of coal are very thin, ….. the attitude of the hodder is almost prone, and …. crawling on hands and knees is indispensable.' (7) The earliest workings would be accommodated within the early gale (8) limit which was defined in the miners' 'Laws and Privileges' as the 'space that ye miner may stand and cast redding [spoil] and stones from him', later increased to 12 yards. The document is dated 1610, but is a copy of an older (possibly much older) manuscript (9). The extent of such workings would be limited by a progressive lack of oxygen, insecurity of the roof, the increasing difficulty of moving coal to the pit bottom for haulage to the surface, and the risk of flooding, which restricted digging to the summer months (10).

The problem of water could be overcome by pumping or by drainage channels or soughs ('surfes' in the Forest). Access to the seams by means of adits or levels would achieve a similar result, if driven from a nearby hill slope, but only where permitted by the lie of the land. Alternatively, a sough might be led to a sump (water pit) and baled by bucket and jack roller. Some early pits may have used primitive pumps operated by men or horses; mechanical pumping came late to Dean, the 'Water Wheel Ingine at Oiling Green near Nailbridge' operating by 1754, was claimed to be the first of its kind in Dean; it was replaced by a steam engine c.1777 (11). Drainage 'surfes' came much earlier, the first mention being in 1637 (12). 'In 1661, certain miners were accused that they had 'dug coal and sunk pits near unto His Majesty's surfe and coal works.' A Commission reported - 'although the ordinary mines could only be dug in the summer, yet the surfe hath made such a passage for the water as they dig the whole year and get a vast quantity of good coal' (13). The Commission recommended, unsurprisingly, that the benefit should be taxed!

In a single shaft mine of limited extent, in cold weather the air at the bottom would be warmer than at the top and natural convection might suffice for ventilation. In hot weather the situation would reverse and there would be no airflow and CO_2 would accumulate, detected by the failing of a candle flame. It might be cleared by putting down slaked lime, or by shaking, say, a jacket vigorously, or by lowering a brazier into the shaft. As mines became more extensive, the presence of soughs or water pits would provide some ventilation, as would the later provision of air passages linked to ventilation shafts, which in some cases were linked to above-ground masonry chimneys provided with a furnace grate, to create an airflow through the workings, as at the Quidchurch shaft still standing on Bradley Hill above Soudley. Such improvements would have led to the development of progressively more extensive underground workings of the pillar and stall type. In this method of extraction, access was through shafts or adits with associated roadways. Unworked pillars were left to support the roof, haphazardly at first, later more systematically (14).

Outputs and the Demand for Coal

Nationally the output of coal increased dramatically during and after the reign of Elizabeth 1st (1558-1603). 'The output of coal in Great Britain doubled and redoubled and doubled again within a century after 1580'(15). It has been stated that 'mineral coal when first employed for [domestic] burning seems to have been essentially the fuel of the less wealthy classes'(16). But coal fires require a chimney. William Harrison, writing in 1587, recorded that old men remarked on 'the multitude of chimneys lately erected, whereas in their young days there were not above two or three, if so many, in most uplandish towns of the realm' (17).

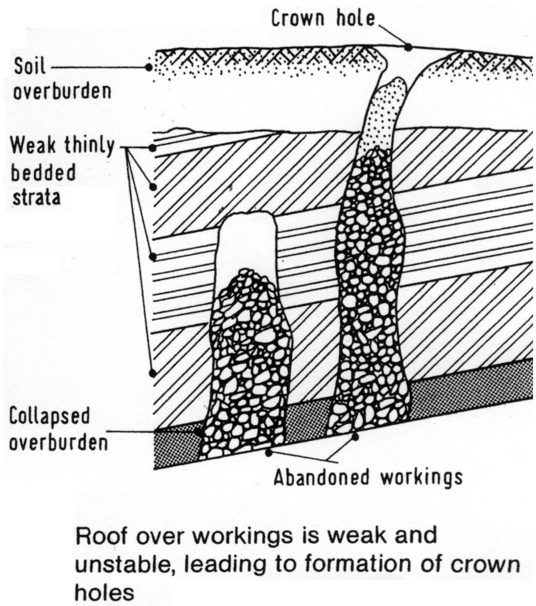


Figure 10. Schematic representation showing the formation of a Crown Hole (After Figure 17b of Reference 14.)

Output in Dean, for long restricted by the gale throwing limit noted above, seems to have increased more slowly, but 'the demand for Forest coal grew to the point when in 1687 the residents of the hundred [of St. Briavels] could not buy enough for their household needs. Merchants and agents from Monmouth and Hereford removed large quantities' (18). As a consequence of increased demand for coal, the gale limits were increased to 100 yards in 1678, to 300 yards in 1692, to 500 yards in 1728 and to 1000 yards in 1754. Nevertheless the early eighteenth century coal mines in the Forest 'were still in a primitive condition …. they consisted generally of levels ….. which served alike for the extraction of coal and the drainage of the workings …. It would appear however that the coal was more commonly raised out of pits connected to the levels. The pits are stated to have rarely exceeded 75 feet in depth' (19). A contemporary observer, Rudder, noted in 1779 'The pits are not deep, for when the miners find themselves much incommoded by water, they find a new one, rather than erect a fire-engine which might answer the expense very well, yet there is not one of them in all this division. They have indeed two or three pumps worked by cranks, that in some measure answer the intention'. By contrast, the same writer noted that at Kingswood near Bristol 'Some of the coal-pits are of prodigious depth. That at Two-Mile Hill is 107 fathoms [642 feet] deep' (20). The shallow Forest workings of this period could be expected to show evidence, in the form of subsidence, on the surface. They may also be responsible for a further type of delve, the crown hole, caused by localised underground collapse, and characterised by the absence of a spoil heap, Figure 10.

'Up till about 1779 …. no steam engine had yet been introduced. The Fire Engine Colliery is mentioned …. In 1788' (21). Collieries in Dean were at last getting deeper, especially after the passing of the Dean Forest Mines Act of 1838. These later, deeper workings are outside the scope of this project, as the shafts will have been filled in or capped, and evidence of underground workings, in the form of delves and surface subsidence, is unlikely.

Interpreting the Visible Remains

The term ‘bell pit’ is used generally by writers on archaeology, including industrial archaeology, to describe features perceived as being evidence of early coal mining. The team’s work has led to us question this view. The workings in Oaken Hill C, exploiting the outcropping Brazilly seam, could well be bell pits, of the ‘thin’ form described on page 11. However the complex group of features at Oaken Hill A cannot be so interpreted. Lidar plots, the team’s ground surveys and the work of Brian Johns, taken together, suggest that these features cannot be bell pits, but a type of galleried working, probably pillar and stall, made possible by progressive developments in pit drainage, ventilation and winding discussed on page 11, and the increases in gale limits noted on page 12. The delves at Oaken Hill B seem to be too widely spaced for bell pits, but Brian Johns' dowsing has shown no indication of galleried working. The delves' spoil heaps contain coal but the seam when reached may have been of too poor quality, or too thin, to justify galleried working.

In 2008, the report of a community project led by archaeologist Martin Roe, to investigate the mining remains in Middleton Park, located 5km south of Leeds, was published. The report (22) includes photographs of the features in the park which closely resemble the delves studied by the GSIA team in the Forest of Dean. The report reviews the documentary evidence and concludes that recorded bell pits are less than 20m deep and 3-12m in diameter at the base, and can be identified by closely spaced shaft mounds on the edge of a coal seam (23). Some of the Middleton Park shaft mounds (our ‘delves’) qualify as bell pits, of a form similar to our ‘thin’ type, Figure 11. However many are 20-80m apart in areas where the seam is deeper. ‘It is immediately clear that even without considering the depth of the seams, the small diameter excavations produced by bell pits would make little sense in this context’. It is concluded that ‘a mining technique such as pillar and stall has been used’. Confirmation comes in the form of a site near Middleton, where modern opencast working has exposed a pattern of bell pits along the outcrop edge, with pillar and stall workings further inwards.

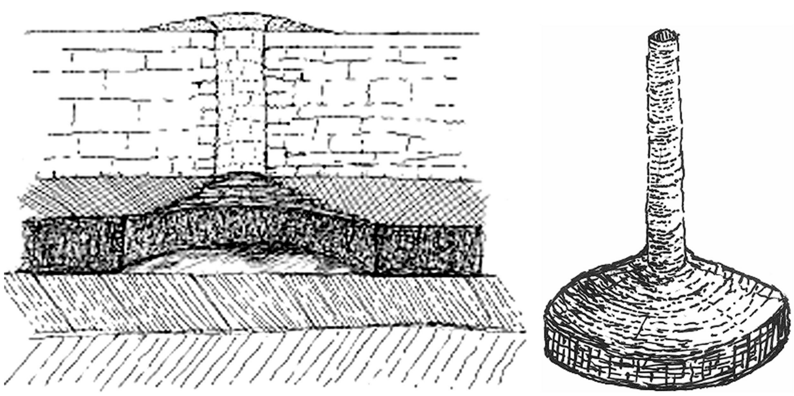


Figure 11. Two models of Bell Pits: Left as a section and right as a three dimensional model. Reproduced by kind permission of the Friends of Middleton Park

Following a suggestion by Ian Standing, the team visited the old workings at Bromley Hill, SO 6007, Figure 12. This site shows clear evidence of progression from bell pit to pillar and stall. There is only one seam, the Yorkley, and the delves are very closely spaced in a band following the outcrop edge, becoming larger and more widely spaced as the seam dips 8-10 degrees and the ground rises at 1:6.

The Middleton report describes a ‘sketch and plot’ method of recording complex earthwork features. This allowed some features to be classified as sites of horse haulage mechanisms (whim gin or cog and rung), or as steam engine sites. This method seems to be applicable to the Forest features and suggests that variations in form of delves, observed by the team but not at present understood, could be elucidated.

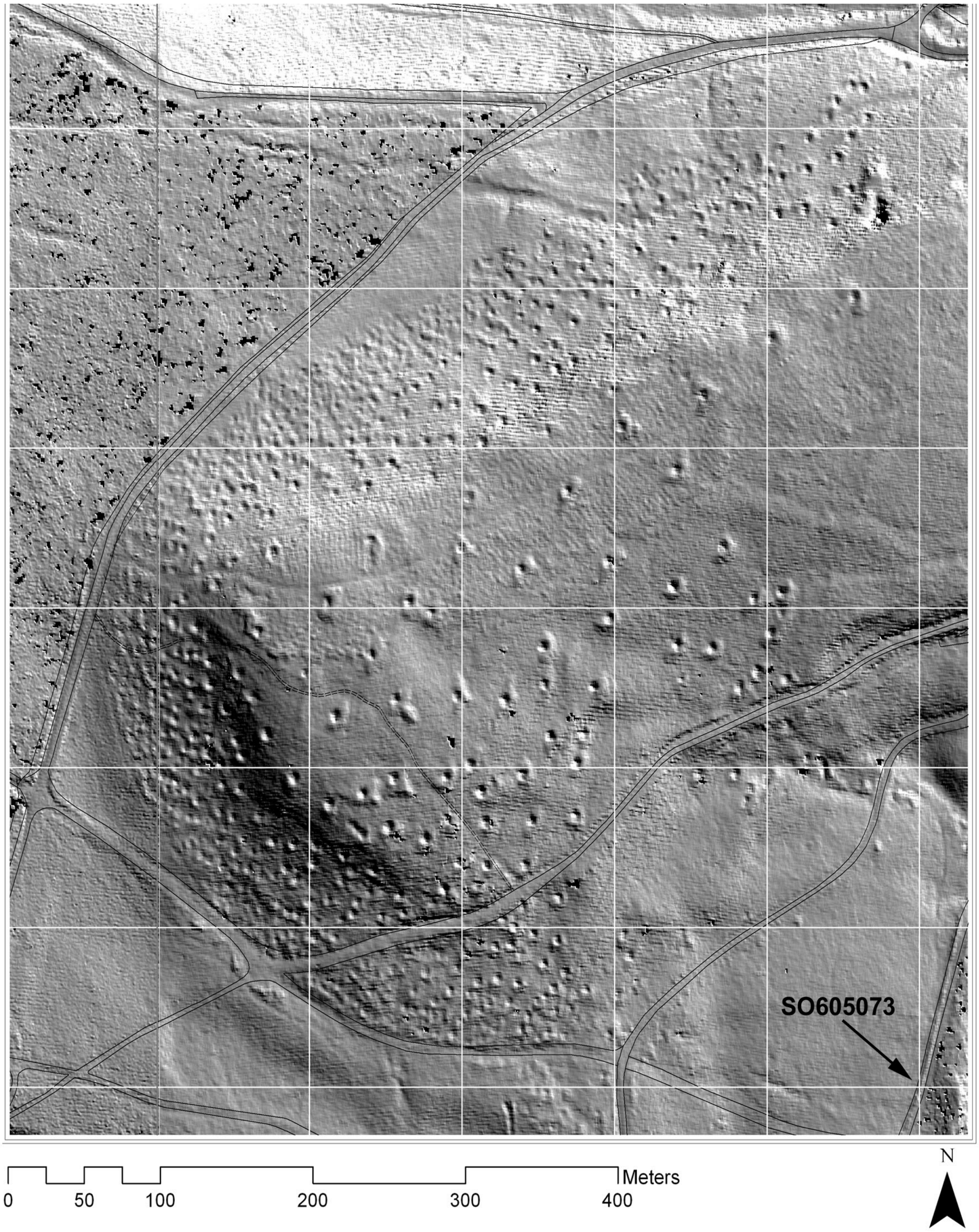


Figure 12 Lidar Image of Surface Workings at Bromley Hill (west of Parkend).

Typology

A preliminary classification of 'delves' can be constructed, as follows:-

Type 1 Open cast pits, adjacent to the outcrop edge.

Type 2 'Thin' bell pits.

Type 3 Shafts descending to underground pillar and stall workings. Sub groups might be identified relating to haulage mechanisms, as at Middleton, noted above.

Type 4 Crown holes, caused by localised underground collapse, characterised by the absence of associated spoil heaps.

Dating

Early mining remains are notoriously difficult to date. Coal mining in the Forest is recorded in the mid 13th century (24) and has continued to the present, though latterly only in the form of a few small free miners' workings. Unfortunately the gaveller's records do not go back beyond the early 18th century (25). Nationally, modern open cast workings have exposed earlier workings and revealed artefacts. Of particular interest is such a site at Coleorton in Leicestershire (26). Artefacts found here such as shoes and clothes are datable stylistically with reasonable accuracy, but of great interest is the tree ring dating of pit props and timber used in shaft construction, making it possible to date the workings to the period from 1450 to 1600. This field is unlike the Forest in that it seems to have been worked systematically, under successive single ownership, over a distance of 1¼ miles (2km), with 300 shafts giving access to the coal. Also the three seams, separated only by very thin dirt bands, totalled 9ft (3m), although some was left to form roofs and floors. Despite the differences, the detailed description of the wooden shaft framing seems highly relevant to the Forest, as is the observation that the technology in use was already established in 1450.

Conclusions

Early coal mining in Dean was of secondary importance to iron ore mining**.** It probably began with shallow pits dug at the edges of the outcrops, developing into thin bell pits. These in turn developed into small scale pillar and stall workings which in turn became progressively deeper and more extensive. Key dates in this process are the first dewatering by means of 'surfes' in the early to mid seventeenth century, the increasing of the gale limits from 12 yards to 100 yards in 1678, to 300 yards in 1692, and to 1000 yards in 1754; the adoption of steam power beginning *c.*1788, and the passing of the Act of 1838**.** It is not yet possible to assign dates to observed features, but as the dowsing has shown that certain delves are linked underground, it seems probable that each linked group corresponds to a gale. If such groups were plotted, the results could be compared to the historical gale limits, hopefully resulting in dating which while not precise, might be within defined limits; for example a working of extent greater than 100 yards but not exceeding 300 yards, would date between 1678 and 1692.

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Notes and References

(1) An engraving from Agricola's book of 1556 showing mine prospecting using dowsing is printed in the Historical Metallurgy Society Special Publication; *Mining Before Powder*, p.91

(2) Further information on Lidar can be found at www.forestresearch.gov.uk/lidar

(3) Harvey, John, Deputy Gaveller personal communication.

(4) Resistivity is defined as the resistance of a cylinder 1m long and 1m^2 in cross-section al area. The unit of resistivity is the ohm-metre (Ωm).

(5) The Geology of the Forest of Dean Coal and Iron Ore Fields HMSO pp56-57.

(6) Roberts, Tony, of Gloucester And District Archaeological Research Group personal communication.

(7) Commission for Inquiring Into the Employment and Condition of Children in Mines and Manufactories Taken from the website of the Radstock Museum.
(8) A *Gale* was granted to a *Free Miner* by the *Gaveller.* 'Prior to the Dean Forest Mines Act of 1838, the Gaveller had to go to the spot selected by the Free Miner, and give him possession by cutting a stick, and cut a notch for every vern or partner the miner has, plus one for the king. A turf is put over it, and the party galing the work is then in full possession'. Treherne Rees in the *Colliery Guardian* Feb. 2 1945.
(9) Victoria County History of Gloucester (VCH) vol.2 p221 considers the miners' Book
o of Laws, from internal evidence, to have been written in pre-Reformation times.
(10) Hart, Cyril, Industrial History of Dean, David and Charles 1971 p.257.
(11) Hart, p.262
(12) Hart, p.258
(13) Hart, p.257
(14) Healy, P.R. and Head, J.H. Construction Over Abandoned Mine Workings. 1984. Construction Industry Research and Information Association p.14
(15) Neff, J.U, The Rise of the British Coal Industry Routledge 1932 vol. 1 pp 14-15.
(16) VCH, vol.5 p.281.
(17) Quoted in Owens, W.R. (editor), Seventeenth-century England: A Changing Culture Vol.1. p.9. Ward Lock, 1980.
(18) VCH, vol.5 p.329.
(19) Galloway, Robert, Annals of Coal Mining and the Coal Trade. 1889, reprinted by David and Charles 1971, Vol.1 p.340.
(20) Rudder, Samuel, A New History of Gloucestershire 1779, facsimile edition Alan Sutton 1977, pp. 36 and 149.
(21) Galloway, p.340.
(22) Roe, Martin, Coal Mining in Middleton Park, Meerstone, Halifax, West Yorkshire, 2008.
(23) Roe, p.18.
(24) Youles, Tony GSIA Journal for 2004 p.5.
(25) Harvey, John, Deputy Gaveller personal communication, 2008.
(26) The Tudor Miners of Coleorton, Leicestershire. Printed in Mining Before Powder, Ref.1 above.