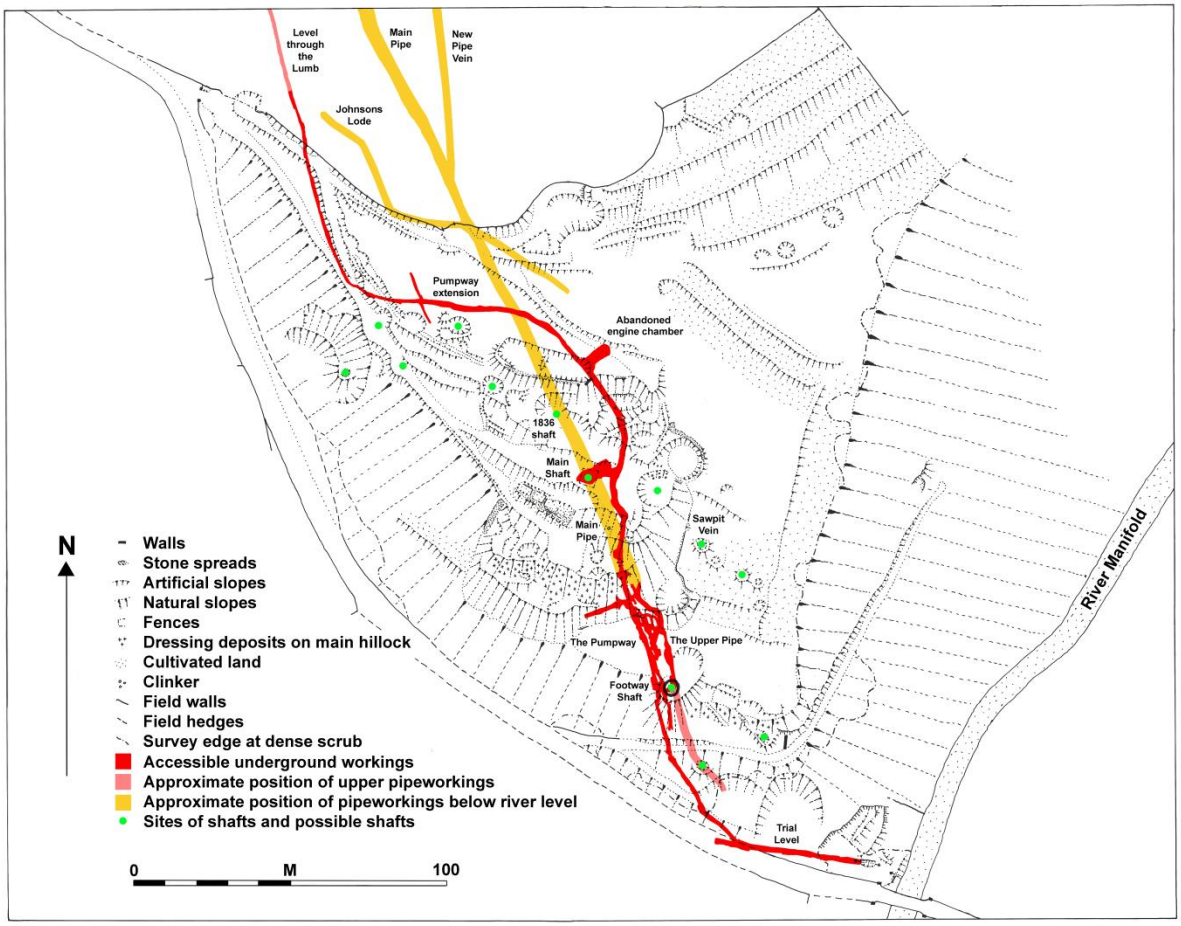
Dale Mine, Warslow:
Survey and Interpretation of a Historically Important Lead Mine



John Barnatt

With a contribution by Terry Worthington

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Cover: Dale Mine – The surface remains and what lies underground.

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Summary

Dale Mine, by the River Manifold at Warslow in the Staffordshire part of the Peak District, was a large lead- and zinc-ore mine; it lies opposite, and historically was overshadowed by, the well-known Ecton copper mines. The mine at Dale was an impressive but challenging 19th century venture, with earlier origins, extracting ore in a large pipeworking that went diagonally downwards from the daleside to a point northwards that was well below river level. While relatively rich in ore at depth, it was plagued with water making it difficult to mine. A series of mining companies attempted to make a profit from the mine but all ultimately failed as the running cost outweighed profits. Shareholders who invested were influenced by the proximity to the rich Ecton mines nearby, believing that the workings at Dale would eventually be just as successful.

In order to meet the challenges presented by the character of the workings, a series of engines were installed through time at deep engine shafts, used to drain the workings into a pumpway at river level and also used bring ore to surface high above. These included Newcomen-type and Cornish-type steam engines, and an underground hydraulic water pressure engine; a large underground waterwheel was proposed but never installed.

While the history of Dale Mine has been studied previously by others, this report concentrates on the surface remains and the accessible workings underground, with detailed metrical surveys executed at both. The results are set against the published historical records to present a more nuanced interpretation of the development of the workings through time; overlying the plans of what remains at surface with what lies below has thrown light on the interpretation of both.

Underground there is a large chamber that contained the c. 1838 hydraulic water pressure engine; today this chamber is the only easily accessible example in the Peak District where such an engine was installed. While the engine itself is long gone, a multitude of notches remain in the walls for timbers that supported this engine and raised floors used for running and maintaining it; these indicators were recorded in detail to see what light could be thrown on the installation of the engine.

Introduction

Dale Mine: This interesting 18th and 19th century lead mine, which also produced zinc, lies high above the River Manifold at Warslow in the heart of the Staffordshire south-western part of the Peak District, centred at SK 0939 5858. On the opposite side of the river are the well-known mines at Ecton; these have always overshadowed Dale Mine but the latter was an important venture in its own right. They were never mined together but lay in different parishes and ownerships, with the miners paying royalties to different people; if the two had been further apart then Dale Mine would be better recognised today as an important historic mine site and given the attention it deserves.

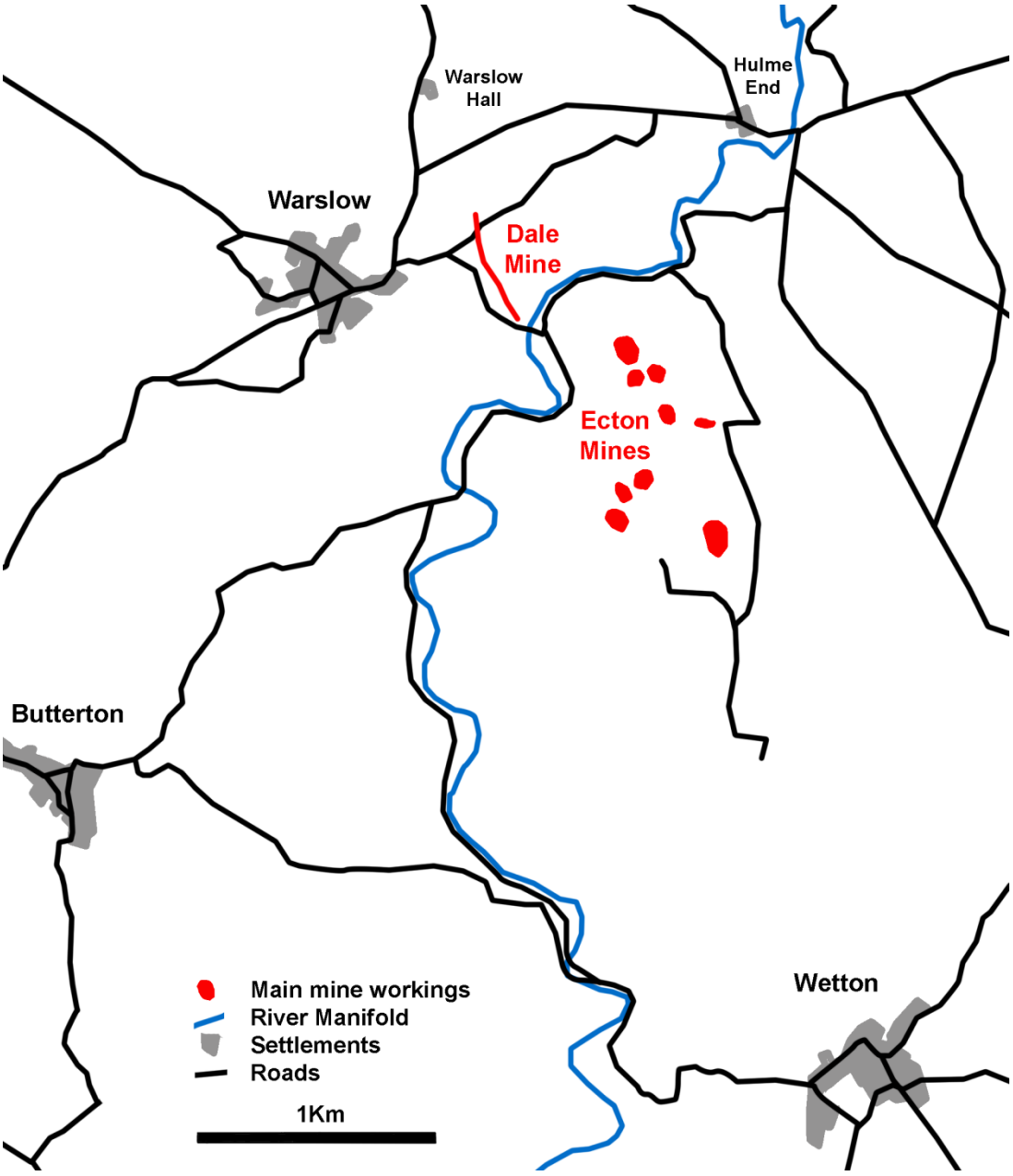

Figure 1: The location of Dale Mine in relation to the Ecton copper mines and local settlement.

Today the mine site lies on Open Access land and is easily visited. It lies within the Peak District National Park Authority's Warslow Moors Estate, which was acquired several decades ago, in lieu of death duties, from the Harper Crewe family of Calke Abbey in southern Derbyshire.

Plate 1: Part of the core area of the Dale Mine site, with the fenced engine shaft site to bottom right, the 'ore bins' lie below, both with access roadways coming from the left. Above are the engine houses quarry and their reservoir, together with another access roadway above and strip lynchets behind this (Photograph: Peter Neville).

Plate 2: Four of the openings through the downslope retaining wall of the bank of 'ore bins'.

High on the daleside there is a variety of surface remains. There include a very large hillock below the main 19th century engine shaft, an engine houses quarry and their reservoir, a bank of six 'ore bins', two gin circles, other blocked shafts and associated hillocks, and a complex series of access roadways. Other important features have gone from view, including three demolished steam-engine houses and the main engine shaft. Down by the river, hidden from the road by thick vegetation, there is the accessible but locked entrance to the Dale Mine pumpway. Above, there are also medieval cultivation strip lynchets and later limestone quarries.

Underground, the upper parts of the Dale Mine workings can still be entered; in contrast, below river level extensive pipeworkings have been flooded since the late 19th century. A long first section of the pumpway that let water pumped from depth out of the mine, driven from just above river level, is still accessible. This leads to two underground engine chambers. One lies at the side of the main engine shaft from surface and once contained a *c.* 1838 hydraulic water-pumping engine. The other, which lies a short distance further along the pumpway, was probably abandoned before it was finished and was either created in the early 1840s or, but less probably, was intended for a large waterwheel planned in 1856; in both scenarios machinery was never installed. There are also small pipeworkings above the pumpway, leading back to the now-blocked Footway Shaft that miners used to gain access to their places of work.

Plate 3: Looking up into the eastern end of the chamber for the *c.* 1838 hydraulic water pressure engine, photographed from next to the main engine shaft (Photograph: Mat and Niki Adlam Stiles).

This paper presents the results of archaeological surveys undertaken with the aim of making a detailed general record of the visible surface remains and the accessible workings underground in order to aid interpretation and raise public awareness of the site. In addition, a detailed record was made of the underground chamber that once held the hydraulic water-pressure engine. These fascinating machines, used to pump water from deep underground, were powered by dropping water down a pipe from surface to operate the pumping engine and were never common. The Dale Mine chamber is the only site in the Peak District that held one and is still readily accessible for study. While the engine itself is long gone, a comparable example can be seen in the Peak District Lead Mining Museum at Matlock Bath recovered several decades ago from Wills Founder Mine at Winster in Derbyshire.

Historical Data and Previous Assessments: Original archive material relating to Dale Mine survives in Staffordshire Record Office, with additional material held in Derbyshire Record Office and in private collections. The known history is very patchy, often only with specific facts given in surviving documents. However, from 1855 to 1868 summary accounts for the

benefit of shareholders appeared in the Mining Journal that allows a more rounded picture for this period. While these reports are very useful guides to how the mine infrastructure was being developed, the optimistic comments on the prospects of the mining should be treated with caution given who they were aimed at. Other papers exist related to a court case in 1871 and depositions made by local people at the time comment on the mine's previous history. No detailed mine account books, minute books or other detailed records survive for any of the mining episodes at Dale Mine.

Previous archaeological assessment has been only cursory, made as part of a regional review (Barnatt and Penny 2004; Barnatt *et al.* 2013), and provisional observations have been given on specific aspects of the mine (Barnatt 2004; Barnatt et al. 2003; 2006; Kirkham 2006).

The known history of the mine has been researched and published previously (Porter and Robey 1972; 1973; 1975; 2000); here the emphasis is on the history of the mine and the people involved, and their various mining interests in the local area and beyond, whereas this current paper places more emphasis on a detailed assessment of the physical remains at Dale Mine and how these inform on its interpretation.

Summarising what we know of the history, with details given below in the section 'The Known History', the first mining that can be certainly ascribed to Dale Mine rather than the general vicinity dates to 1766, by which date it was already ongoing. From the late 18th century onwards a series of eight relatively short lived companies and groups of individuals were active at the mine until it closed in 1873. It was primarily worked for lead ores, but zinc ores were also recovered, particularly from the mid-1850s onwards. Although the mine is just across the river from the Ecton Mines, famous for its copper output, copper ores were not present in economically viable quantities at Dale Mine.

One of the key features at Dale Mine is the installation of engines to facilitate pumping and winding from the pipe deposit below river level. The first documented steam engine at Dale Mine was almost certainly of Newcomen-type and was used for pumping. This was probably here by 1807-11 and may have been in use previously for some time; the engine house, with engine inside, was still standing in 1823 when the mine reopened after several years of closure. The new company do not appear to have used it and in 1830 an old boiler, of probable haystack type, was removed from site. The mine reopened again in 1836 and the new company took down the old engine house, digging out its foundations, and erected a building on its site to be used for storing ore. Rather than using a steam engine at surface, they installed a hydraulic water-pressure engine underground for pumping, which was in the process of being installed in 1838; this engine worked until 1843. After a short period when the mining was confined to working above river level, yet another new mining venture erected a small second-hand steam winding engine of Cornish-type in 1854-55, with a 19 inch cylinder diameter, which was used at Dale Mine for pumping. A second and larger second-hand Cornish-type pumping engine, with a 40 inch cylinder diameter, was brought from New York Mine a few kilometres to the west, with this engine and its buildings erected at Dale Mine in 1859. When this was installed the small pre-existing engine of 1854-55 was converted for use as a winding and crushing engine. In 1861-63 a new shaft was sunk to the north-west, well beyond the area surveyed in 2018, and the 19 inch cylinder engine was transferred to here in 1862 and used in the same way as before at its new location. Pumping in the new workings continued to be powered from the pumping engine installed at the old engine shaft in 1859, with a series of flat rods at surface installed in 1863 that ran to pump rods in the new shaft. This engine also worked underground flat rods and pumps via the old

engine shaft. After the mine closed in 1873 the 1859 engine house was presumably purposefully demolished given that no ruins exist today. That for the smaller engine had already been blown up in the early 1860s, when the engine here was removed to its new site.

The surviving historical documentation also informs on: the presence of other buildings, including an ore house, a smithy, a carpenters shop and a mine office; on the use of horse-drawn winding whims; the extent and character of the worked mineral deposit; on shafts and underground levels, the latter including a pumpway for letting out the water pumped from below river level into the River Manifold; and on ore processing and pollution of the local water supply by the mine.

Plate 4: Nigel Sharpe surveying the surface remains with an EDM, with Peter Neville assisting.

Fieldwork and Survey Methods: The surface survey was undertaken in August 2018 by John Barnatt and Nigel Sharpe, with others helping, and covered much of the field in which the main Dale Mine remains sit. However, large parts of the steep main daleside slope to the south-east are covered in impenetrable scrub and it was impossible to record what if anything lies here; the edge of this un-surveyed area is shown on the survey plan. Elsewhere across the site there are intermittent patches of scrub where it was impossible to record small parts of features adequately but enough could be seen to be confident of the general depiction of features and hence the extent of these scrub patches was not recorded. Because there is no mobile phone signal over much of the site the survey was done using a Total Station EDM. Sub-metre accuracy GPS was only used in the top part of the site for placing survey stations, as here there was mobile phone reception that allowed the survey as a whole to be fixed to Ordnance Survey mapping; Beacon Land Survey Ltd processed the data. For each feature

surveyed a large series of points were fixed to within 100mm real accuracy (as the survey was to be presented at 1:500 and this is far less than a thin pencil line). These points were measured using the EDM at tops and bottoms of slopes, edges of walls, quarries, etc. They formed a skeleton upon which hachures and other details could be appended by John Barnatt from sketches of all features made at the time. In late September and early October 2018 the hachure survey was checked in the field by John Barnatt, with minor amendments and additions made, and further notes were made to allow completion of the feature catalogue. Heights of features, for the most part, were estimated with the aid of a ranging pole. Survey work was complemented by aerial photographs taken by Peter Neville one of the EDM survey assistants.

Plate 5: An example of the aerial photography undertaken at Dale Mine, with patches of scrub overlying archaeological features, with a particularly large one between the gin circle near the main engine shaft to the left and the wall Footway Shaft to the right (Photograph: Peter Neville).

The underground workings were surveyed intermittently between April 2015 and March 2016 by John Barnatt and Terry Worthington, with others helping. Work was undertaken in three stages, following procedures established previously (Barnatt 2013b). Firstly, a line survey between fixed stations was carried out, with horizontal and vertical bearings taken to the nearest degree and distances between instruments at adjacent stations measured using a hand-held laser to the nearest 0.01m. Secondly, passage detail was added for each survey leg using right-angled offsets from a straight line between each pair of stations; measurements were taken to the nearest 0.05m, which provided suitable accuracy for the survey drawing at 1:200. Thirdly, once the survey was drawn-up in pencil, copies were taken underground for checking and where necessary minor adjustment. More importantly, archaeological details were added where not already recorded in stage two; this included making a detailed record of notches, etc., in the hydraulic water-pressure engine chamber.

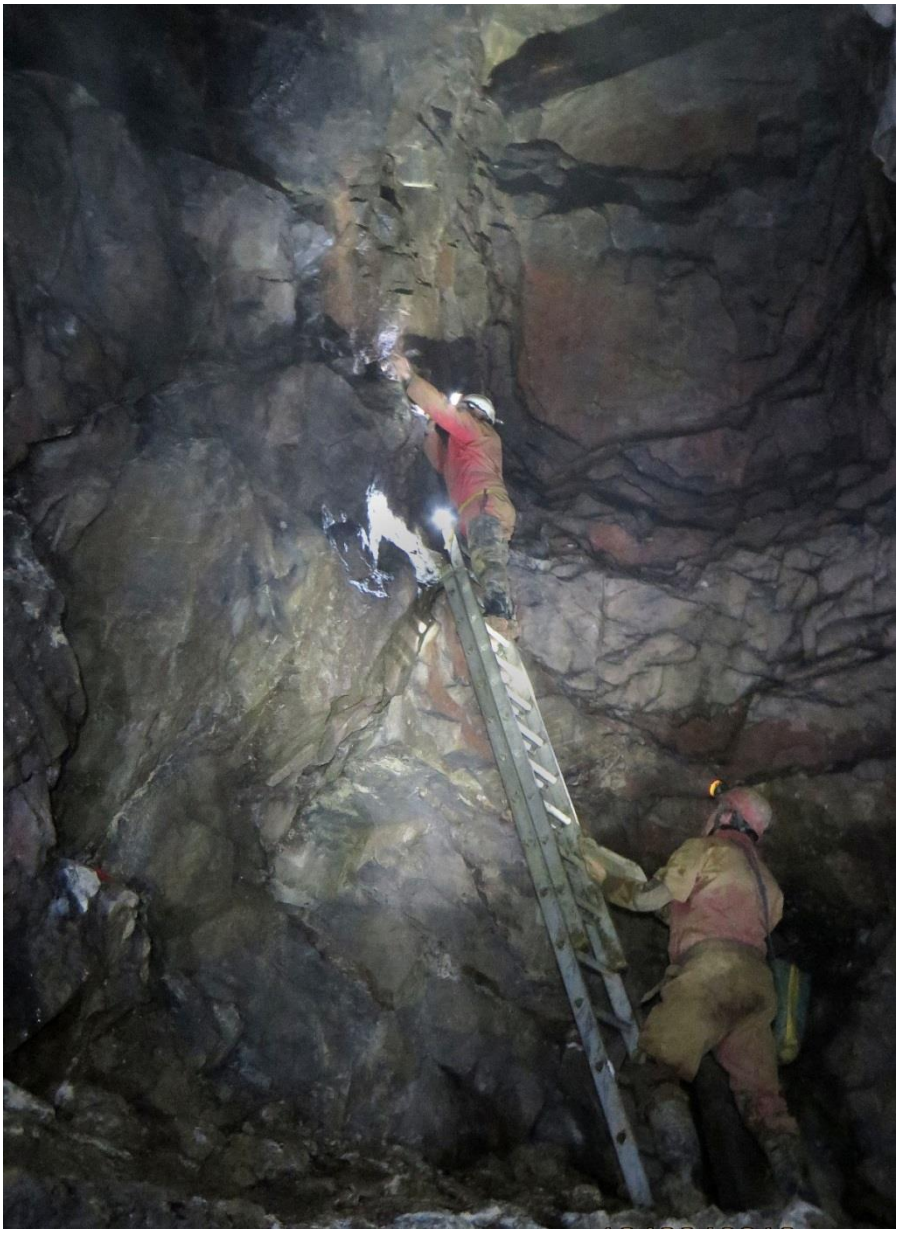

Plate 6: Terry Worthington, assisted by John Barnatt, measuring notches for timberwork in the main engine shaft chamber (Photograph: Rod Dalton).

Surface Survey

Overview: At the heart of the site there is a core area of mining remains focussed on a now-capped engine shaft, with two adjacent platforms at the sites of three engine houses and other buildings, with a nearby upper dressing floor. A quarry for stone used for the buildings and the engine house reservoir remain. Nearby there is a fine gin circle next to a hollow that may well be the site of a second shaft. Immediately below the engine house, on the downslope side to the south, there is a substantive but part-robbed waste hillock. On a terrace here there lies a lower dressing floor with a standing but dilapidated bank of stone built tanks with downslope openings, interpreted here as ore bins. All these features, with the exception of the reservoir, lie within a ruined belland yard wall.

Outside the core area there are further mining remains. Downslope is the filled Footway Shaft, surrounded by a ruined wall, on the summit of a large waste hillock; nearby is a probable gin circle and a small dressing floor. Elsewhere there are hillocks at a further six to nine shallow shafts, two of which are on a short line of shallow vein workings. The outcrop of the main mineralised pipeworking is lost but two potential sites have been identified. At the base of the steep dale-side close to the River Manifold there is the locked entrance to the mine pumpway where accessible underground workings can be entered. Between here and the river there is a flat-topped hillock above a slabbed bolt that took water from the pumpway to the river; nearby there is the site of what may have been the mine office.

In the upper part of the site there are features related to water management, with this used for ore dressing and supplying the underground engine. These comprise a dressing floor leat following the contour, with a short terrace below interpreted as once having supported a launder. At the top of the site there is a slight gully heading straight towards the main engine shaft that may well mark the site of a launder for water that was taken underground here to the hydraulic water-pressure engine.

An important part of the mine archaeology is a series of access roadways leading to the core part of the mining remains, with others leading to stone quarries.

There are also non-mining archaeological remains on site, including limestone quarries, some for stone and others for limeburning, and small stone getting pits. To the north-east and east of the mining remains there are strip lynchets formed during medieval arable cultivation.

The Main Mine Complex: At the centre of the core area of mining remains is the site of the main engine shaft (Fig. 2: A). This has been covered with timbers and soil and is no longer visible but its site is surrounded by a fence to keep people and vehicles off. To the north and east sides of here there are low and rather poorly defined flat platforms that we know from documentation once had mine buildings that were purposely demolished. The first (Fig. 2: B) is likely to have supported a Cornish-type engine house initially used for pumping but later converted for winding and ore crushing. The second (Fig. 2: C) had a Cornish-type engine house used for pumping, which replaced a smithy with a carpenters shop nearby. An early Newcomen-type engine house, later replaced by an ore house, stood on one of these platforms, most probably that to the north of the shaft. To the west of the engine shaft there is a flat featureless area that we know from documentation was a dressing floor where a variety of timber-built equipment stood. To the north there is a *c.* 4.0-5.0m deep stone quarry (Fig. 2: D), with two main pits and waste heaps, that may well have provided stone for mine buildings. To the east there is a well preserved gin circle (Fig. 2: E) that is terraced into the slope by just under 2m on the upslope side, with made-up ground on the downslope side

where this is supported by part of the belland yard wall (see below). Adjacent is a *c*. 1.5m deep hollow on top of a high but very overgrown hillock (Fig. 2: F), which may well mark the site of a second shaft. The hollow and other parts of the hillocks nearby to the south-west have deposits of boiler clinker at surface that must derive from the steam engine boilers. Above all the features just described there is a well preserved engine house reservoir (Fig. 2: G), which supplied water to the steam engine boilers and presumably the dressing floors. This is rectangular in plan and has a 0.7m high bank across the middle, with a gap at its south end that may well have been for a sluice, dividing the pond into two similarly-sized compartments. The reservoir is cut into the slope at the upslope side by about 1.5m and the downslope side is embanked by *c*. 2.0m; the latter is surmounted by a ruined belland yard wall (see below).

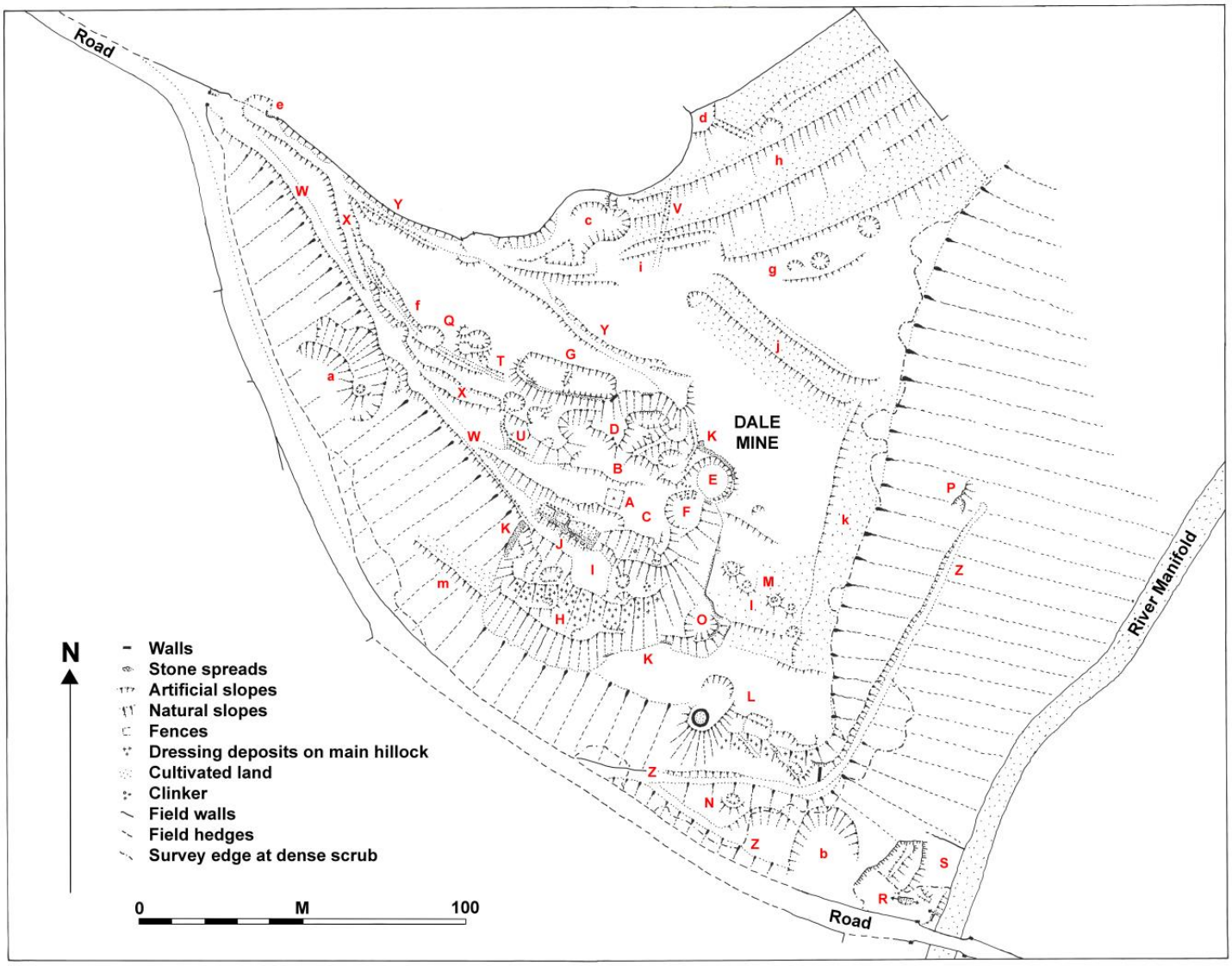

Figure 2: The archaeological surface survey at Dale Mine (for mining features A-Z, and other features a-m, see text).

Plate 7: The main working area around the fenced site of the capped main engine shaft (Feature A), with flat platforms at the sites of engine houses immediately behind and to the left of the shaft (Features B and C). To the far left are the spoil heaps of the mine's stone quarry (Feature D). The 1788 Ecton Hill engine house is visible on the skyline above.

Plate 8: The eastern half of the stone quarry on the upslope side of the engine shaft (Feature D), which is thought to have provided stone for building some or all of the three engine houses, two of which once stood on the flat platform in the foreground.

Plate 9: The gin circle (Feature E) east of the main engine shaft and the surrounding ruined belland yard wall (Feature K). The hollow behind with gorse bushes is at the site of a second shaft and the site of the main engine shaft is out of view to the right.

Plate 10: The two-compartment engine house reservoir (Feature G), with its downslope side surmounted by the ruined belland yard wall (Feature K). Ecton Hill looms behind.

To the south side of the features just described, downslope of these, there is a massive waste hillock that is about 13.0m high on the downslope side, large areas of which are still un-vegetated (Fig. 2: H). For the most part this comprises pieces of limestone that must derive from shaft sinking or working underground through barren ground. In addition, on the gentle slopes part way up the hillock, immediately below the next two features to be described, there is smaller material exposed that make up the hillock here in its present form, which is likely to derive from ore processing. The upper half of the hillock, including the material just noted and the surrounding ground, is irregular and looks heavily robbed, including one area where a flat-topped terrace has been created after robbing. In contrast, in the hillock's lower part, its side is significantly steeper.

On the flat-topped terrace on the hillock noted above, at about 5.0m below the level of the main engine shaft and upper dressing floor, there are two important features. To the south-east there is a flat-topped lower dressing floor (Fig. 2: I); this may well have been used for the final stages of ore processing with equipment such as buddles, after this had been crushed on the upper dressing floor west of the main engine shaft. Coming from the north-west there is a narrow flat area approached by an access roadway, with a stone structure on the upslope side (Fig. 2: J).

Plate 11: The lower dressing floor (Feature I), with the bank of 'ore bins' behind (Feature J).

This unusual feature, suggested below as likely to be interpreted as ore bins, has no known architectural parallel elsewhere at a mine site in Britain. It is a complex stone-built structure comprising a set of six vertical-sided tanks built in a line following the contour, with a high wall on the downslope side with six openings, leading into the now rubble-choked tanks behind (see Plates 2, 45); the downslope side of this wall, which is up to just over 3.0m high, has had its face robbed. Presumably this face was of ashlar and was taken for reuse elsewhere after the mine was abandoned; there is a low heap of discarded material adjacent to much of the length of the wall where this robbing took place. Differences in the design of the

openings show that it may be a two phased structure, with four identical close-spaced openings to the south-east and two differently-built openings to the north-west, with these set further apart and slightly further back compared with the other four; this is matched by the differently-sized tanks behind the wall. There is no obvious butt-joint between the two halves of the wall and an alternative explanation also needs consideration; that they were all built at the same time but with the two larger north-western tanks functioning differently from those to the south-east.

Plate 12: The south-eastern end of the ruined bank of 'ore bins' (Feature J), with rubble-choked tanks visible.

The six openings have complex designs, details of which are given in Appendix 1. In summary, at the four to the south-east each has a tapering arched entrance, with a now rotted-away square timber frame at the inner end; here the lintels of the four openings appears to have been one long timber placed above them all. Beyond the timber frame, going inwards, the openings are *c.* 0.60m square and continue through the wall to the tanks' inner faces where the interiors of these are choked with rubble. Each of the vertical walls of the inner openings is built of stone but with remaining traces of render covering the stonework; the roofs comprise now-rotted timber planks and beams. At the north-westernmost of the four openings, a fully-rotted timber here had a small metal pipe running vertically through it that is still *in-situ*. Above these four openings the retaining 'wall', actually comprises two walls running parallel to each other, matching the width of the inner and outer parts of the four openings, with a narrow gap between that matches the position of the long timber frame lintel. This slot may have contained mechanisms for sluices in the openings below.

Plate 13: One of the openings into the four 'ore bins' to the south-eastern end of the bank of six, with the rubble filling the tank behind visible at the back (Feature J).

Plate 14: The top of the retaining wall of the south-eastern 'ore bins', showing the two adjacent wall faces with a gap between that matches the position of the long lintel at the timber frames in the openings below; the other faces of the two walls have been robbed in both cases (Feature J).

The two north-western openings are of different design but again have outer and inner parts. The outer sections have vertical sides and had a horizontally-placed timber lintel above; that to the north-west has rotted away. At the inner end of each of two outer parts of the openings in their top halves there are vertical 'blocking' walls, each of stone and brick, with render in parts over the brickwork, and with a small inner opening below. At the south-easternmost opening there is a metal pipe protruding from the stonework above the bricks. Below the upper blocking wall, only visible at one opening with the other being buried, there is an iron plate surrounding the small inner opening. There are bolts protruding from the plate and these may well have fastened a timber frame in place; to the sides, where the outer edge of the frame would have been, the stonework is rendered so that the timbers would fit neatly. Whether these frames were for a door or sluice in not known. The 'opening' that the metal plate defines is just over 0.80m wide, with the height not assessable as the lower part is buried. However, an opening through the inner wall to the tank behind is only *c.* 0.30m wide; why the plate 'opening' is wider than this is not known.

Plate 15: One of the openings into the two 'ore bins' to the north-western end of the bank of six, with an iron plate surrounding the partially choked inner opening visible at the very bottom, with an iron pipe in the back wall above to the top right (Feature J).

Plate 16: Detail of one of the openings into the two 'ore bins' to the north-western end of the bank of six, showing the metal plate and the small inner opening beyond (Feature J).

Plate 17: A corner of one of the 'ore bin' tanks, with intact walled vertical sides remaining; elsewhere much has collapsed, been robbed or is buried behind rubble (Feature J).

Plate 18: The 'ore bin' tanks had rendered sides and intact *in-situ* fragments of this are still visible (Feature J).

The tanks themselves had vertical walls but only intermittent fragments of their facing stones are currently visible; much of the lower halves of the tanks are rubble filled, while the upper parts of the walls have been robbed and/or collapsed. The walls were covered in render, fragments of which remain *in-situ*. The four rectangular tanks at the south-eastern end, with long axes to NE/SW, each have the downslope openings placed approximately central to their tank. In contrast, the two rectangular tanks at the north-western end are each roughly twice the size of the other four, with their long axes at NW/SE, with their openings in the south-western corners. It is not known whether the individual bins were used for different types of ores, or alternatively to distinguish which ores were mined by different groups of miners.

Interpretation of this structure is convoluted and a detailed debate is given in Appendix 1 (Feature 11). In summary, previous interpretations as limekilns or zinc ore calciners are rejected here; the timber components in the openings make these explanations impossible to sustain. The most likely interpretation is that they are ore bins where part-dressed ore from the upper dressing floor was held and washed, before being dressed further on the lower dressing floor; an alternative explanation as settling tanks/filter beds seems far less likely.

Surrounding all the features described above, with the exception of the engine reservoir, there is a ruined and now only intermittently-visible belland yard wall that defines a roughly oval area (Fig. 2: K), which curves sinuously to take in the core-area mining features and was designed to keep grazing livestock off poisoned ground. This was either built in a late phase of mining or after this had ceased.

Other Mining Features: Beyond the main mine complex there are further mining features. These include the now-backfilled Footway Shaft to the south east and its associated hillock, probable gin circle and ore dressing area (Fig. 2: L). This shaft has been surrounded by a now-ruined drystone wall that was probably added after it fell out of use but was still open; the wall top may well have been pushed down the shaft when it was backfilled. The hillock is nearly 5.0m high on the downslope side and may include material cleared from the natural parts of the pipeworkings below as well as the shaft sinking debris. On the upslope side to the north-east there is a large flat area, which is terraced into the slope with a curving arc at the edge that is up to 1.2m high, strongly suggesting that a horse-drawn winding whim once stood here (see Plate 37). The implication of this is that while the shaft was eventually used as a footway for access to workings at depth, it was first sunk as a winding shaft for bringing up ore from the upper pipeworkings. Above a steep natural break of slope running south-east from the Footway Shaft hillock, there is irregular ground with a series of sharp breaks of slope at the upslope edge that are *c*. 0.5m to 0.7m high. While the north-western and south-eastern ends of this area are irregular and may comprise dumped material, at the centre there are two flat-topped rectangular terraces with a 0.3m high break of slope between them. These may well be dressing platforms given the character of the material deposited on the steep slope below. At eroded surfaces here there is a fine, orange-brown coloured, mineral sand with small angular stones. This was probably dumped here after washing and buddling the ore within cave deposits brought from underground to extract ore from within them.

Plate 19: The robbed wall surrounding the Footway Shaft (Feature L).

Plate 20: The dressing area next to the Footway Shaft that lies behind (Feature L); the large hillock of the main engine shaft covers a large part of the slope above (Feature H).

Plate 21: A surviving fragment of drystone field wall, on an artificial terrace, with exposed fine redeposited material on the steep slope behind, dumped from the ore-dressing area above next to Footway Shaft (Feature L).

Also in the south-eastern part of the Dale Mine site, to north and south of Footway Shaft there are several features associated with shallow mine workings. Those to the north (Fig. 2: M) comprise a line of four or possibly five features on a vein. Two of the small hillocks here, which are 1.3m and 0.9m high on their downslope sides, are probably associated with shallow shafts, while the others are likely to be opencast explorations along the length of the vein. The larger shaft hillock to the north-west within main mine complex (Fig. 2: F) is on the same line and may be an equivalent to the Footway Shaft on the pipeworkings, but placed on the vein that here runs roughly parallel to these.

The mining remains to the south of Footway Shaft include a small shaft hollow and hillock that is *c.* 1.7m high on the downslope side (Fig. 2: N), located on the steep slope below an access roadway (Fig. 2: Z), and another possible example nearby to the east on the terrace utilized by the roadway where the latter bends to the north-east. The remains at the latter may be alternatively interpreted as where the pipeworkings came to surface, but this feature is well out of line with where the outcropping is thought likely to be. Alternatively, the pipe deposit may have first been found in a 'quarry-like' hollow south-east of the certain small shaft on the steep slope (see Plate 38); this area has impenetrable scrub and adequate assessment of this possibility proved impossible.

Two other nearby features need to be mentioned. In the south-west 'corner' of the belland yard (Fig. 2: K) there is an embanked and walled out area (Fig. 2: O). This is likely to be mining related and of early date but there is no shaft here unless it lay nearby and has been

Plate 22: This embanked and walled area (Feature O) is located below the main engine shaft hillock to the south-east 'corner' of the belland yard wall (Feature K). It is likely to be mining related and predating the hillock seen behind to the right that overlies one side of the area.

Plate 23: The vegetation-covered pack at the small trial quarried face (Feature P), located on the steep daleside to the east of the main mine complex.

subsumed by the main mine hillock (Fig 2: H). Although roughly circular, the ground is rough and it is very unlikely there was a gin circle here. On the steep daleside to the east there is a small trial delve (Fig. 2: P), approached by a terraced access roadway (Fig. 2: Z), with a short, 3.0m deep, quarried face abutted by a small 1.0m high pack of waste stone; while the possibility that this is mining related cannot be discounted, there is no known mineralisation in this vicinity and it may be a trial stone quarry. In either event building the access roadway would have involved a significant amount of work and, for reasons unknown, the stone removal here must have been aborted soon after it was started.

To the north-west side of the main mine complex there are between two and five sites of further shallow shafts (Fig. 2: Q). One certain example is a relatively prominent feature north-west of the steam engine reservoir (Fig. 2: G), with a hillock that is just under 2.0m high on the downslope side (see Plates 27 and 36). A second probable example lies in the deep limestone quarry to the west (Fig. 2: a); this has a hillock that is just over 2.0m high on the down slope side and it may be that mineralisation was discovered during the quarrying. Between the two shafts just noted, an access roadway to the main mining complex (Fig. 2: W) has two bulges at the downslope side that may be explained as mine hillocks with their associated shaft hollows filled when the roadway was built. The final possible example lies just south of the south-east corner of the reservoir; this has a prominent hollow at the top of a mound that is just over 1.5m high on the downslope side, which could be alternatively interpreted as a mine water-storage pond although this second explanation seems less likely.

Plate 24: A hollow, with upcast heap on the downslope side, at what may well be at the site of a shallow shaft (Feature Q), located just south of the south-east corner of the mine reservoir (Feature G).

At the south-east corner of the Dale Mine site, next to the river, is the entrance to the Dale Mine pumpway (Fig. 2: R). This lies within a vertical-sided cutting, just over 2.5m deep, defined on the north side and west end by quarried bedrock. The entrance at the west end was originally *c.* 1.5m high and *c.* 1.5m wide but it was walled up several decades ago and there is a more recent hole cut through this wall in its northern half near floor level; this has a locked gate installed over ten years ago. The cutting appears to be an original purposefully-made feature, providing a foot access point to the rock-cut level. The water from the level runs down a well-defined channel at floor level in the northern half of the cutting. At the eastern end it enters a covered bolt, with drystone walled sides and a top of horizontally placed slabs, which is 0.45m high and 0.50m wide. This drain runs under a flat-topped, and in part ill-defined, waste heap. At the eastern end of this there is an exit point for the drain, with a short and shallow, vertical sided, channel leading from here to the river. The bolt exit is set in a part-ruined drystone wall built parallel to the river bank, with up to 1.6m visible height, part of which, to the south side, is still extant. Here the south wall of the bolt remains, up to 0.65m high, but the roof and other side have collapsed.

Nearby there is the site of a building on a flat riverside terrace that has gone without leaving surface traces (Fig. 2: S). The Ordnance Survey 25 inch to a mile map of the area surveyed in 1878 shows a rectangular building here; the second edition of this map shows it had been demolished by 1897. The building stood within a yard that extended to the road and took in the pumpway entrance and platform (Fig. 2: R). A dwelling near the river was documented as being occupied in the early 1870s and there was also a mine office somewhere in the same vicinity; one or both are likely to have stood at Feature S.

Plate 25: The partially walled-up entrance to the Dale Mine pumpway (Feature R).

Plate 26: The covered bolt that takes the water from the Dale Mine pumpway to the river (Feature R).

Water Management: Returning to the main mine complex there are three features related to water management in addition to the steam engine reservoir described above. To the north-west side of the main engine shaft and upper dressing floor (Fig. 2: A) there is an embanked leat following the contour and heading towards a point above the dressing floor. This leat is only narrow and up to 0.3m deep (Fig. 2: T). At the south-eastern end it seems to be truncated by the downslope embankment of the mine reservoir (Fig. 2: G), although as an earthwork it fades to nothing shortly before the mounds edge. The origin of the water in the leat is not clear, but upon entering the survey area it may have run alongside one of the access roadways (Fig. 2: X). This water course is likely to date to the earliest use of the main engine shaft, as it follows or is overlain by the roadway, which in itself is early and was later superseded. The leat would have become redundant at a relatively early stage, as it was replaced, first by another leat associated with the underground hydraulic water pressure engine (Fig. 2: V) and then by the reservoir.

Plate 27: A narrow embanked leat (Feature T) immediately below a hillock for a shallow shaft (Feature Q) west of the main engine shaft area. The leat, heading towards the photographer, took water to the upper dressing floor (Feature A).

A short distance downslope of the leat just described there is a short section of narrow linear terrace that possibly marks the site of a launder following the contour and heading towards the nearby upper dressing floor (Fig. 2: U). To the west, unless the water was dropped from the leat above, the launder would have been raised above the land surface so it has left no visible footprint. Again this feature is likely to be early in date and to have been later superseded.

At the upslope side on the main mine complex there is a slight gully, up to about 0.3m deep (Fig. 2: V), which heads downslope directly towards the main engine shaft (Fig. 2: A), but fades as a visible feature in this direction. It is probable that this gully is the site of the end section of the long leat that came from west of Warslow Hall (Porter and Robey 2000, p.

113), which provided the water to be piped down the main shaft to power the underground hydraulic water-pressure engine. If this is the case then the gully would have held a wooden launder that was for the most part set on the natural ground surface but was cut into the ground where the terraced ground with strip lynchets was crossed (Fig. 2: h).

Access Roadways: Approaching the main mine complex from the north-west there is a series of access roadways, all terraced into the slope and suitable for carts. There are clear signs of chronological depth and changes to the layout through time, provided by slight lynchets formed across the ends of early sections where they are intersect later routes, and also by one roadway being overlain by other mine features.

The last-used access route (Fig. 2: W) heads to the engine shaft, the adjacent sites of two Cornish-type engine houses and the upper dressing floor (Fig. 2: A-C), while a branch to the right led below and was used to take out processed ore from the lower dressing floor (Fig. 2: I, J).

Plate 28: The main access roadway used in the late phases of mining (Feature W), leading diagonally downslope to the engine shaft area to the right, with a lower branch down to the lower dressing floor and 'ore bins' hidden by the small trees here; Ecton Hill lies behind.

Earlier access routes can be identified where they were on a different line to what came later; in other parts some of these early routes were followed by the final access road arrangement. A certain early route (Fig. 2: X) comes down the slope diagonally before heading to the main engine shaft along the route also used later (Fig. 2: W); there was a branch leading left to above the Newcomen engine house that was presumably used to bring in the engine and perhaps its coal. Another access route (Fig. 2: Y), which leads down to the top of the main mine site, was probably used to bring in coal for the steam engines, but also could have perhaps been used earlier for the same purpose; a branch to the left at the slope top leads to a limestone quarry (Fig. 2: c) and it is unclear which of the destinations provided the impetus for the initial construction of the north-western part of the access roadway. Alternatively, its south-eastern part could have been created at a late date as part of a roadway created to

access the new shaft well to the north-west of the area surveyed, which ran through the limeburning quarries immediately north of the survey area.

Further down the slope, below the main mine complex to the south-east, there are two further bifurcating access roadways (Fig. 2: Z). These may have been constructed to access limestone quarries rather than mining features. One led to an aborted trial on the steep daleside (Fig. 2: P), the other to what is perhaps a quarry where the Dale Mine pipe deposit outcropped (see above); interpretation of both these destination points, in terms of whether they are mining or quarrying related, is far from clear.

Stone Quarrying: the Dale Mine site also has archaeological features that are not primarily mining related; these include limestone quarries. Along the steep slope of the side valley to the south-west side of the site there are quarries that were dug for bedded limestone rather than for limeburning kilns. To the west there is one dug into thinly bedded stone that is about 7m deep on the upslope side (Fig. 2: a). Close to the river there are two or possibly three conjoined quarries, all heavily vegetated and difficult to assess in detail (Fig. 2: b). That to the east, cut into solid limestone beds and with a floor on two main levels, has an upper face that is up to *c.* 6m high and a lower one that is *c.* 2m high; this quarry almost certainly pre-dates the Dale Mine pumpway entrance that lies at its base. Immediately to the west there is a second quarry that is very approximately 5m to 10m deep and appears to be dug into thinner beds as there is no deep vertical rock face. Further west a similar hollow, approached by an access roadway from the north-west (Fig. 2: Z), is about 4m deep on the upslope side and may also be a quarry; it could be that the Dale Mine pipe mineralisation was first found here.

On the main daleside to the east there is a small aborted working approached by an access roadway (Fig. 2: Z); as noted above this may be a failed quarry or perhaps a trial mine working (Fig 2: P).

Plate 29: One of the limeburning quarries at the top of the site (Feature c), with the main limeburning quarries behind in the trees beyond the field wall.

To the north of the main mine complex, mostly beyond the area surveyed, there are a series of large conjoined quarries that, in contrast to those to the south, were dug in conjunction with limeburning. Three small features associated with these lie within the survey area and may well date to a period before the field wall here was added. They comprise: a moderately-sized quarry that is over 3.00m deep (Fig. 2: c), which is conjoined with larger quarry on the north side of the field wall and is approached by an access roadway (Fig. 2: Y); a small waste heap of another quarry to the north (Fig. 2: d); and one corner of a ruined limekiln (Fig. 2: e).

Scattered across the site there is also a series of small stone-getting pits, presumably dug to provide limestone for field walls and other structures; there are concentrations of these to the north-west (Fig. 2: f) and north-east (Fig. 2: g) of the main mine complex.

Strip Lynchets: On the gentle to moderate slopes above the steep daleside there are a series of strip lynchets that are almost certainly of medieval date. The main block lies to the north-east (Fig. 2: h). Here there are four main strip lynchets running parallel to each other following the contour, with short stretches of two to three further lynchets on the same alignment. For the most part all these lynchets have sharply defined tops but in some cases the bottom of these enhanced slopes are indistinct. They range between about 0.5m and 1.0m high. Not all the ground between the lynchets has been cultivated and below the second and third main lynchets from the top there are long gaps where there is a gently-sloping unmodified natural slope. A bottom *c.* 0.5m high break of slope below three stone-getting pits has no associated cultivated ground and this may well be a natural feature. To the south-west end of the main lynchets of the north-eastern block there is a narrow terrace (Fig. 2: i), which may be an access trackway to the cultivation strips on lower ground to be described below; however, the possibility that it is a particularly narrow cultivation terrace cannot be discounted. A short distance further west there is a possible lynchet, or perhaps a natural break in slope, that is 0.80m high.

Lower down the slope there are further strip lynchets on different alignments to those described above. They mostly align NW/SE and in a central area there is a large gap where the ground is steeper and unsuitable for cultivation. At the top there are two well defined cultivation strips (Fig. 2: j); the two parallel lynchets here both curve eastwards at their bottom ends. That to the north-east is about 0.3m high while that to the south-west is 0.5m high. The former is bank-like in that a very low feature above the lynchet showed as a difference in vegetation colour in the parched condition on the day of survey. The land to the north-east of this does not look to have even been cultivated. Following the edge of the steep daleside there is a single probable cultivation strip (Fig. 2: k) roughly at right angles to those just described, which has an indistinct lynchet, up to 0.40m high, at its north-western edge. Further down the slope there are two or possible three lynchets (Fig. 2: l) that run parallel to those further up the slope. These are up to 0.7m high, with the lowermost effectively forming a headland to the cultivation strip at the daleside-top noted above, while that furthest upslope doesn't appear to have associated cultivated ground and it may be a natural break of slope. These cultivation strips may well have extended further north-west but here they are overlain by the hillock of the main mining complex (Fig. 2: M). Beyond this there is a single possible lynchet, or a natural break of slope, that is 2.0m high (Fig. 2: m).

Observations: Based on the archaeological evidence taken alone, important interrelationships between surface features can be determined from their placing and horizontal stratigraphy:

- At the core of the site there are a series of features that together form the focal point for deep mining at Dale Mine. These include: the main engine shaft and nearby features related to steam engine houses; a stone quarry used to build these; a gin circle for a horse-drawn winding whim; upper and lower dressing floors with 'ore bins' between them; and a massive waste hillock that has been modified through time.
- The unusual row of stone-built tanks between the two dressing floors have been given various interpretations over the years; they are reinterpreted here as 'ore bins' for the storage and washing of part-processed ores.
- While the central mine complex, largely defined by the ruined belland yard, is the focal point for deep mining at Dale Mine, there are features within the wall to the east side that may well be earlier in date, including the shaft with hillock and gin circle, the last also used later, and an area that is uncertainly interpreted within the south-eastern 'corner' of the belland yard.
- There are a series of shallow shafts outside the area defined by the belland yard, most or all of which are likely to be early in date; this includes the Footway Shaft with its gin circle and adjacent dressing area.
- The main Dale Mine pipe deposit must have outcropped on the steep daleside south-east of the main mine complex, but survey has failed to identify the exact location with any certainty.
- To the north of the main mine complex, a slight gully is an important feature in that it may well mark the site of the launder that brought water to the main engine shaft that was used to take water down to an underground hydraulic water pressure engine.
- There is evidence that water was brought from the north-west to the main mine complex for ore dressing at an early phase, at a time before water was available via the launder just noted and later via the steam engine reservoir.
- The main mine complex is accessed by a series of roadways; these have chronological depth, with routes redefined through time to meet the needs of the mining as new extraction and ore processing infrastructure was introduced.
- There are a series of stone quarries on the ground surrounding the main mine complex, some to the north associated with limeburning, others to the south dug as limestone quarries; all are roughly contemporary with the mining.
- The earliest surface archaeological features in the area surveyed are the strip lynchets of probable medieval date; these cultivation strips did not cover all of the sloping ground above the steep daleside; only the most favourable areas of ground were used.

All these relationships will be returned to below in 'Interpreting Dale Mine' after historical data has been assimilated.

Underground Survey (JB and TW)

Overview: Today there are 604m of accessible underground passages at Dale Mine, of which 434m are in the pumpway. These figures include a modern dig at the inner end of the pumpway that is 83.5m long; this was not surveyed in detail and is not shown on Figures 3, 5 and 16.

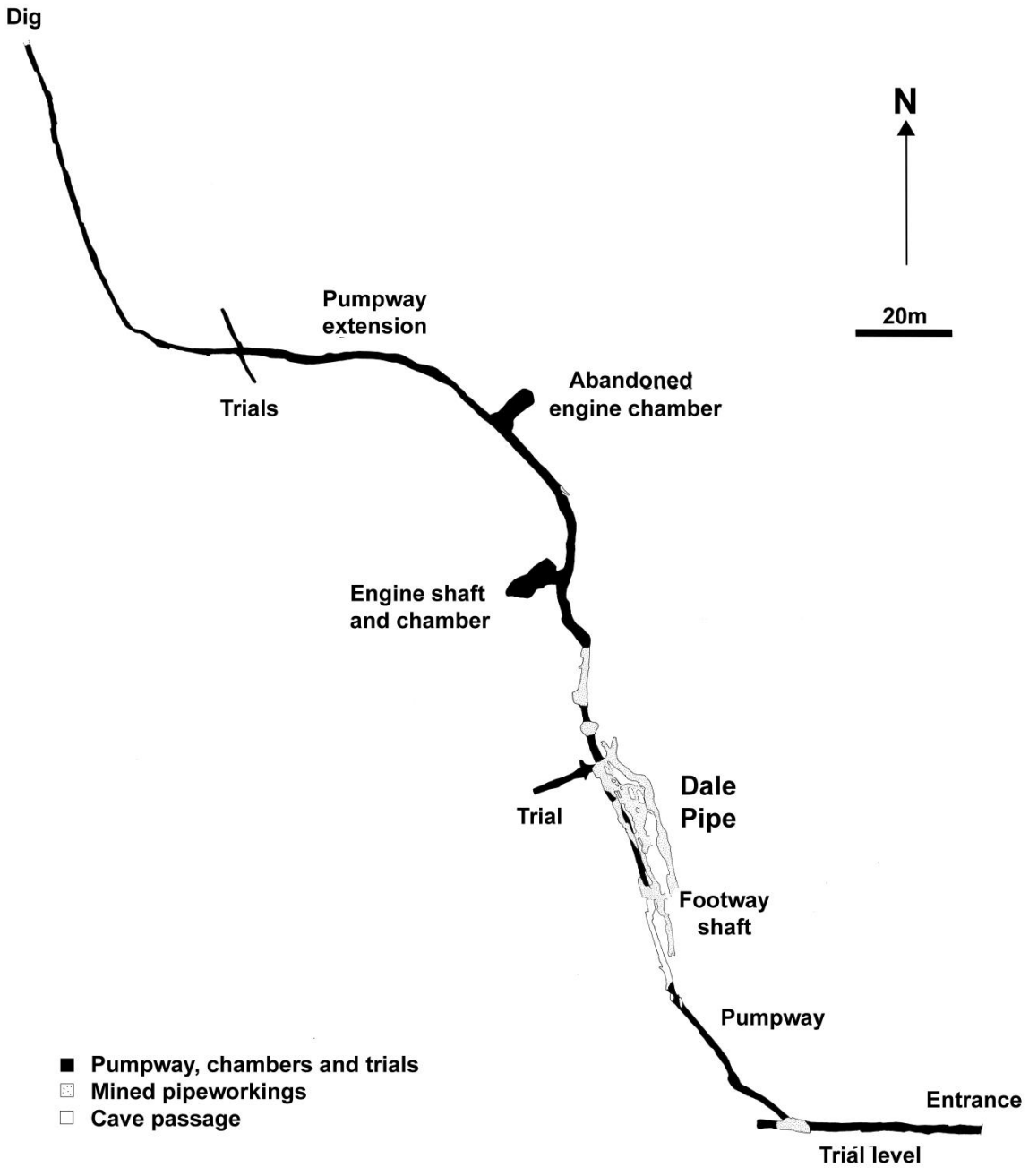

Figure 3: The archaeological underground survey at Dale Mine; overview showing all passages assessed.

The first section of the passage inside the entrance was almost certainly driven as a short trial looking for mineral before the pumpway was created. The pumpway branches north-west from this near its end and after 37m it intersects small pipeworkings, both along its course and in passages above, with the latter leading up towards the backfilled Footway Shaft. Once

the pumpway was in existence this route provided the main access point for miners to workings below. At the northern end of the accessible pipeworkings these drop below river level and have been permanently flooded since the mine pumps were turned off in the 1870s. Here the pipeworkings were intersected by the mine's main engine shaft. This comes vertically from surface and at river level there is a large engine chamber offset from the shaft to the north-east side. This is documented as containing the hydraulic water pressure engine erected in *c*. 1838 but a surfeit of archaeological details here may suggest there may have also been other equipment installed here; the shaft itself, and perhaps the chamber, may well have been created earlier than the 1830s but with the chamber heightened when the water pressure engine was added.

Beyond the engine chamber the pumpway becomes more sinuous, for reasons that are unclear turning slowly westwards before then going back to a north-western heading. At 40m after the entrance to the main engine chamber there is a second large chamber on the north-eastern side of the pumpway. This had been abandoned, almost certainly before some form of engine was installed here, and was subsequently partially backfilled with deads. Along the pumpway as a whole there are two places where trials looking for mineral have been driven. The first leads south-westwards from the pipeworkings and was unsuccessful. The second, beyond the second chamber, follows a narrow vein in both directions and may well have been soon abandoned because this was unproductive.

The Pumpway and Pipeworkings: The pumpway is entered close to the River Manifold, with it driven slightly above river level from the base of the steep daleside slope. At the entrance there is a 20th century brick wall, built to seal the passage and prevent entry (Fig 4: A); this has subsequently been broken through by mine explorers, but with the new hole now containing a locked gate. A short distance inside the passage there are the stub walls of an earlier barrier (Fig 4: B); this may well have been built when the pumpway was in use and presumably these walls flanked a door. This first straight section of passage is a trial for mineral, ending after 48.5m at a forefield.

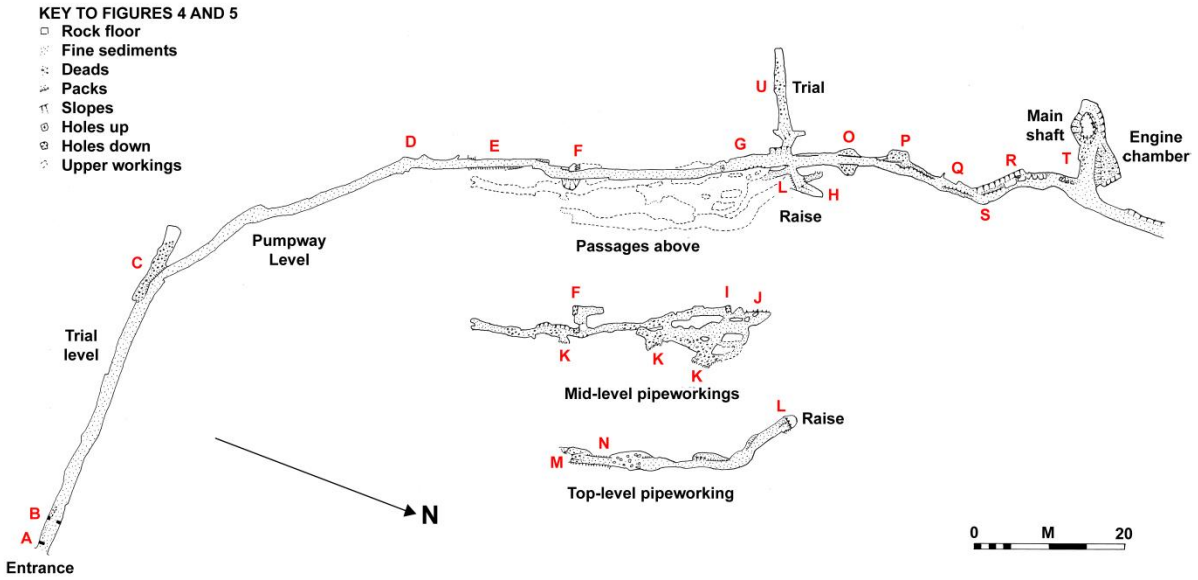

Figure 4: The archaeological underground survey at Dale Mine; south sheet (for A-T see text; for the northern continuation see Figure 5).

About 6m short of the forefield, the pumpway was driven off at an angle from a small natural chamber, presumably at a later date than the trial; the end of this trial was partially backfilled with deads retained by a pack wall at the side of the new pumpway (Fig 4: C). The first section of the pumpway drivage followed a geological fault through un-mineralised limestone, which haded increasingly as the passage went north-westwards. After 26m it intersected a natural passage (Fig 4: D), then followed this for 21m. The first section of this natural passage is a narrow but relatively high phreatic rift, but also with low wider parts of the natural passage near floor level, with a long section to the east side and a small passage to the other side both walled off (Fig 4: E). After becoming less-regular, the natural section ends at a hole in the roof to upper workings (Fig 4: F). Beyond the hole the pumpway then again followed a fault though barren limestone, with this on a somewhat different orientation to the fault in the first part of the pumpway drivage. This passage ran for 37m before the pumpway again re-entered the pipeworkings (Fig 4: G). After 7m beyond here the natural passage heads off north-east for 3m and then turn towards north for a further 3m where it slopes downwards, beyond which it is fully flooded (Fig 4: H).

Plate 30: In the pumpway level, near its start, with left wall at a hading fault (Photograph: Mat and Niki Adlam Stiles).

Plate 31: In the pumpway level where it passes through a high but narrow natural passage with water-worn sides; a wider section of passage to the right has been walled off (Photograph: Mat and Niki Adlam Stiles).

In the opposite direction, running south, small upper pipeworking passages can be followed above the pumpway on two upper horizons. The lower of the two can be entered at three points through holes in the pumpway upper-side and roof (Fig 4: F, I, J). At this mid-level part of the pipeworkings there are 83.5m of passages over a 40m long stretch, comprising a complex series of irregular interconnected and part-choked small pipeworkings of crawling height. For the most part, natural sediments have been sorted and the finer material removed, whilst deads have been left in heaps on the floor. In three places to the east side there are rising workings choked with the deads (Fig 4: K); these deads were dumped from above, from the top level pipeworkings, which were once inter-linked with those below.

The top-level pipeworkings are entered today from the pumpway horizon via a 'raise' with a walled side within a vertical section of natural passage that is a little over 4.5m high (Fig 4: L). From here they run southwards for 34m, ending at a choke with the material here having come from above (Fig 4: M); this is the base of the blocked Footway Shaft visible at surface. Once the pumpway was in existence this footway was the main way for miners to get down to the workings below river level. The accessible part of the footway passage is relatively sinuous and largely natural; sediments have been partially removed. As these were worked small packs of deads were placed to the sides to the north, while to the south pack walls from floor to roof are more continuous and define the sides of the footway (Fig 4: N). At the northern end of this section there has been a roof collapse and part of the 'new' roof here is potentially unstable and the passage should not be entered.

Returning to the pumpway horizon, going north from the complex series of passages just described, the level, over a 26m stretch, was started through un-mineralised ground but soon intermittent natural pipeworking passages were broken into. The first of these is a mineralised 'vugh' that is up to 3.7m wide (Fig 4: O). The second is a natural cave passage that is 3.2m wide and relatively high (Fig 4: P); when formed this natural passage was larger than today and there are *in-situ* clay-dominated sediments in the roof still infilling its upper part. Both of these isolated pipeworking passages have low packs to the side of the pumpway. Beyond the last natural section just described the pumpway follows a low modified cave passage (Fig 3: Q), with notches for horizontal stemples inserted to give roof support, while extending north from here the pumpway has a natural roof at an open bedding plane, with the rock below removed to create the level here.

Much or all of the whole 26m of pumpway just described presumably has filled pipeworkings extending down under its floor, or had fissures leading down to these; the bulk of the pipeworkings here were probably now below the pumpway level, dipping further as they went northwards, and only upper parts were intersected by the drainage passage. Today water sinks at one point in the southern 'vugh' (Fig 4: O). Throughout this length of passage, originally there were sturdy wooden launders, with a flat base and vertical sides, installed to contain the water pumped from depth via the main engine shaft and thus stopping it re-entering the workings below. Parts of two of these launders survive, the first next to where the water sinks, the second further south, both now displaced to the passage side but still on the floor up to about ten years ago. That to the south is a 3m long plank, presumably from the base of the launder. That to the north is better preserved, comprising two 4m long planks at the base and one 2cm thick side plank. The launders in this section of pumpway were originally set on horizontal beams close to the passage floor, with notches for these still to be seen in the passage walls. In contrast, running north from the remaining launders there are intermittent survivals of a stone-built launder-support plinth. This is 0.2-0.3m high, in part with a remaining flagged top. The surviving sections are placed to the passage side, with the

plinth changing from one side to the other for a short stretch. Beyond where the pumpway passes through the part-natural passages, the plinth extends through a sinuous pumpway passage cut through un-mineralised limestone (Fig 4: R), going northwards to the entrance to the main engine shaft chamber; the plinth's total length is 22m.

Plate 32: The surviving northern timber launder in the pumpway level, recently moved from the floor and leant on its side (Photograph: Mat and Niki Adlam Stiles).

Plate 33: Part of the stone-built support plinth for the launders in the pumpway, with a small pack supporting a boulder above to the left (Photograph: Mat and Niki Adlam Stiles).

The sections of pipeworkings accessible today, at the pumpway horizon and above, comprise small, largely-natural, phreatic cave passages. These originally extended diagonally upwards from the pumpway to beyond the footway to the south, while further north the pipeworkings descend gradually below the pumpway horizon, eventually becoming entirely below this, with the pumpway here driven entirely through un-mineralised ground above. The bulk of the mining in the accessible parts of the pipeworkings seems to have comprised removal of sediments, which were dominated by silts and clays that presumably were to one extent of another mineral rich. In small areas the walls themselves are mineralised, with calcite dominating, but there is virtually no sign of metal minerals. In contrast, at the far end of the

accessible pumpway, where the modern dig is, the level passed through a long section of ground filled with clay and boulders; this, known locally as a 'lumb', again may be a naturally filled cave passage but there is no sign that mineralisation or ore-rich deposits existed here.

Beyond the section of pumpway in the pipeworkings, from where the passage kinks (Fig 4: S), the accessible pumpway extends for a further 195m to the beginning of the modern dig, with no significant mineralised deposits encountered at this horizon. This passage gradually bends westwards and then after some distance bends again to the north-west, coming back to a similar orientation to the first section of the pumpway.

At 12.5m from the beginning of this long section cut through limestone, to the west side there is a side passage (Fig 4: T), leading immediately to the main engine chamber with its shaft from surface at the far end; both are described below.

At a further 40.0m northwards, there is the entrance to a second chamber, this one on the north-east side of the pumpway (Fig 5: A). This had been abandoned, probably before it was ever used, partially backfilled with its entrance at the side of the level walled up; again it is described in more detail below. Between the two chambers the curving passage has been partially widened, with some of the shotholes larger in diameter than those encountered elsewhere in the accessible workings, with these driven in such a way as to suggest it was the intention to install pump-rods between the northern chamber and the engine shaft; this widening was not finished and the rods never put in place.

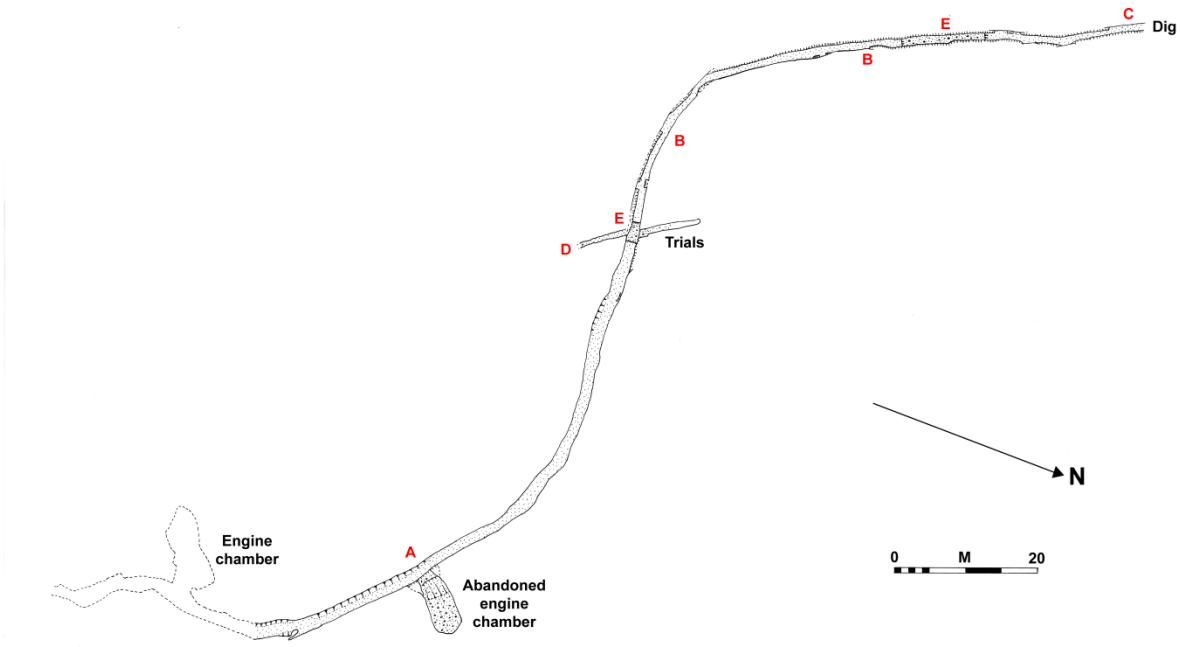

Figure 5: The archaeological underground survey at Dale Mine; north sheet (for A-E see text; for the southern continuation see Figure 4).

Going further along the pumpway, at first it has the same orientation as before and is following an un-mineralised fault, but after 16.5m it veers more to the west through barren rock. Over a 32m stretch there is a series of drill holes at the north-eastern side of the passage about half way up the wall (Fig 5: B). Some of these still retain rotted wooden plugs and this line of holes and plugs may have once each contained small iron hooks; these may have held a signalling wire or they were used during drivage for hanging lights. These hooks may have continued north-westwards down the rest of the accessible passage but evidence for this is now obscured by near-continuous modern packs of material from the dig beyond that narrow the width of the passage. In contrast, at the beginning of this modern dig there is a sturdy iron hook set high into the western wall (Fig 5: C). A line of six of these hooks was visible extending inwards before the modern dig was undertaken (Porter and Robey 2000, p. 112). They were designed to support large natural boulders in the passage roof and once have had an '*iron bar*' running between them (Rieuwerts 1961).

Plate 34: The eastern part of the chamber next to the main engine shaft, which held the hydraulic water pressure engine, with a high roof cavity at the end and a later pack below. The reused rails in the foreground once supported a platform over the end of the now-flooded shaft (Photograph: Mat and Niki Adlam Stiles).

The Chambers: The main engine shaft chamber (Fig 4: T), with irregular blasted walls, is 11.5m long, 3.5-4.5m wide and 6.0-6.5m high, with a roof cavity at the east end where there was an original total height of 11.5m before the lower part of the chamber was filled with a pack. This chamber has a large number of features, found on both sides and at the east end, many of which are likely to be associated with the *c.* 1838 hydraulic water-pressure engine placed here, while others may be for other installations, such as a balance bob, and these are perhaps of earlier date. Most comprise picked notches and slots for timbers, some of which are joist slots for two timber floors at different levels part way up the chamber, while others are for large machinery support timbers, and there are a variety of others where interpretation of the function of the timbers is not clear. There are also several iron pins, some with looped ends and one comprising a double staple, while other pins helped hold timbers in place. All of these features are described in Appendix 2 and discussed below in some detail in the interpretation section, under 'Hydraulic Water-Pressure Engine'.

On the floor of the chamber in its eastern half there is a large pack of deads with a battered wall that is up to 2.5m high. It was presumably added after machinery had been removed from the chamber.

The engine shaft lies near the western end of the chamber. It descends vertically from surface and is *c.* 1.8m across at the chamber roof. At the chamber floor the shaft going to depth is larger, at 3.5m long and 1.6m wide. This difference suggests that the half of the shaft going below the floor nearest the pumpway had a special purpose. It probably held pump rods and pump pipes; that it was for the water-pressure engine itself can be discounted because of its documented pumping beam (see 'Interpreting Dale Mine - Hydraulic Water-Pressure Engine' below). There are two rails protruding over the shaft here at just below the chamber floor level. It is very unlikely there was ever a tramway here and it may well be that they have been reused from elsewhere and are likely to have supported a platform, allowing close inspection of what was positioned here.

The second chamber (Fig 5: A), located further along the pumpway, with its near end offset from it by about 1m. It is just over 8m long, about 3.5-4.0m wide and originally was about 6.75m high. The chamber may well have been abandoned before it was finished as no shaft from surface enters its roof. The interior of the chamber has been substantially backfilled with deads and at the north-eastern end these reach to about 3.0m from the roof; these deads were presumably added when the pumpway was extended. The chamber is the correct shape and size for an engine of some description and no alternative explanations are apparent for a space of this shape and size. There is no sign of an associated shaft going downwards, but this cannot be fully discounted as the whole floor of the chamber is backfilled.

Trials: There are two trials driven off the pumpway, as well as several places along this where mineralisation was given cursory investigation. The first trial (Fig 4: U) lies to the western side of the section of pumpway where it runs through the pipeworkings. This was driven 14m south-westwards, near the beginning passing through a minor fault with calcite mineralisation but, other than this, it failed to find more mineral deposits. It has been partially backfilled with clay and deads. The second trial lies in the far reaches of the accessible pumpway (Fig 5: D). Here the pumpway intersected a small vein that was followed for 8.5m to the north-west and at least 6.5m in the opposite direction to where it is now blocked by a fall; both passages have been partially backfilled with material from the modern dig. Above the pumpway, at the intersection with the vein, there is a small raise going upwards, created to investigate the vein at a higher level.

Plate 35: The south-western end of the abandoned engine chamber, part backfilled with deads, with the pumpway extension out of clear sight below the figure climbing up (Photograph: Mat and Niki Adlam Stiles).

The Dig: The un-surveyed dig at the end of the accessible pumpway is about 83.5m long and is propped and shuttered throughout. Much natural clay and stones were encountered during the dig and, while the much of the clay was flushed out, the stone was stacked further back in the pumpway, either at the sides or in two pack filling the lower half of the pumpway (Fig 5: E). Unfortunately, but inevitably, parts of the walls of the original passage were obscured behind packs and the whole passage is now covered in clay from the diggers' clothing.

Observations: Turning now to the accessible passage as a whole, brief comment on the relative dates of parts of the workings can be made, given here based on the archaeological evidence alone. There are various chronological relationships:

- The horizontal stratigraphy of the trial passage at the entrance and the pumpway branching from it almost certainly indicates the former is earlier in date than the latter.
- At other mines often differences in shotholes size can give indications as to relative dates of mine passages (e.g. for the Ecton Mines see Barnatt 2013a, pp. 129-32); however, at Dale Mine this is not the case. Throughout the length of the accessible passages the vast majority of shotholes are of similar size, ranging from about 20mm to 24mm diameter. The only exceptions are those of about 30mm diameter in the abandoned engine chamber and the section of pumpway between here and the main engine shaft. Even these large holes are mixed with other smaller-diameter shotholes. However, those in the pumpway section are demonstrably associated with widening the passage and contrast with the other side of the passage where the shotholes are of 20-22mm diameter; with the former they are driven outwards while the latter are driven inwards and relate to the initial creation of the passage.
- The section of pumpway between the two engine chambers has certainly been modified, probably for the insertion of flat rods that ran from the abandoned engine chamber to the main engine shaft in the other chamber. However, the chronological sequence for the two chambers is not clear from the archaeological evidence; different scenarios could apply and these are returned to in the section below on 'Interpreting Dale Mine'.
- Although we know from historical documentation that the pumpway was extended in the early 1860s, from a point somewhere beyond the two engine chambers to a new engine shaft well to the north, there are no clear indications as to where this new work started; the first part of the pumpway beyond the abandoned engine chamber, extending for an unknown length and perhaps at least as far as The Lumb and the modern dig, may pre-date the 1860s.
- Lastly, on archaeological grounds alone, the small size of the accessible pipeworkings and their character, suggests the workings above river level cannot have produced much ore and this part of the mine was never profitable. However, we know from historical documentation that, as with the workings at Deep Ecton and Clayton mines across the river (Barnatt 2013a, pp. 153-85, 272-303), the workings became richer at depth.

All these relationships will be returned to below in 'Interpreting Dale Mine' after historical data has been assimilated.

The Known History

This section draws heavily on previous published research by Lindsey Porter and John Robey (1972; 1973; 1975; 2000); no attempt has been made to revisit the various archives they accessed for the present study.

The 18th Century: The Dale Mine site has long belonged to what eventually became known as the Harper-Crewe Estate. Although records exist of mining rights leased by Henry Harper from the early 18th century onwards, the first definite mention of mining at Dale Mine was in 1766 when a rich '*vein*' of lead ore here was found and worked for at least three years. In 1767-68 John Harper recorded in a notebook that '*a lead mine beyond ye copper mine, near to it but a little further up ye river, now working again*'; the copper mine referred to was at Ecton and a sketch plan confirms the lead mine was Dale Mine (Derbyshire Record Office, D 2375M/63/55). This notebook entry suggests the mining at Dale Mine started before the mid-1760s. The mine lay next to a turnpike road authorised in 1770, a section of which ran from Warslow down to Ecton, which gave a good communication route to and from the mine.

Dale Mine Company (c. 1790s - 1810s): In 1795 when the Warslow Cotton Mill near Brownslow Bridge south-west of the village was put up for sale it was noted that it was near a mine that was shortly to be started by Sir Henry Harper. While this venture may well have been elsewhere in the local vicinity, probably a trial against Warslow Brook, it was worked under the aegis of the '*Dale Mine Company*' of which little is known except that they were active from the 1790s. The main partners were John and Peter Daykeyne and one of the 23 others involved in the company was Sir Henry Harper. It may well have been this company that installed the Newcomen-type engine at Dale Mine. John Farey, who had been collecting information from 1807, wrote in 1811 that '*the mine engines at any time used in the district'* included those *'at Dale and Haybrook-Gate, in Warslow, Staffordshire*' (Farey 1811, p. 338). However, he also followed this by saying that in 1810 the only mine pumping engine driven by steam was at Lady-gate Mine at Matlock Bridge in Derbyshire suggesting that the one at Dale Mine and the other at Haysbrook just over 1km to the north were disused by then. A deposition for an 1871 court case made by Sam Fynney noted that Dale Mine was in work in 1812 when he took up residence in Warslow; it may have closed relatively soon afterwards.

Warslow Mineral Company (1823 - c. 1830): In 1823 George Cantrell took out a lease from Sir George Crewe to work the various mines on his estate on behalf of the Warslow Minerals Company. Cantrell had been the manager of the Duke of Devonshire's mines at Ecton until sacked in 1819 due to a personality clash with John Taylor the recently appointed agent (Porter and Robey 2000, p. 72; Barnatt 2013, p. 214).

A valuation of Dale Mine made at the time the Company was set up gives details of the pre-existing steam engine, describing this as having '*one small cylinder, 18 inches diameter with cylinder and cylinder bottom and columns, counter and steps of beams and old arch heads with chains and one boiler, 5½ feet diameter, in bad repare and a few old pipes*'. It was valued at £35. 15. 6d and this must have been little more than scrap value; the engine was clearly disused by this date.

All that is known of the company is ownership was divided into 24 shares and that there were 18 partners, the principle one being Richard Gaunt. In 1823 two calls were made on the shareholders that raised £2,400. An undated inventory of the Company's assets makes no mention of the old steam engine and its pumps; presumably they had been disposed of by the time it was drawn up. In this underfunded operation, which worked at a relatively small scale,

water was being raised in barrels using a horse-operated gin. The 1870s affidavit by Samuel Fynney stated that this attempt to drain Dale Mine failed. Other people could remember a round boiler with concave bottom being sold in about 1830; this was almost certainly the haystack boiler from the old Newcomen-type engine. This date could be when the Company ceased operations here and elsewhere in the vicinity, although the possibility of it continuing until as late as 1836 cannot be discounted.

The North Staffordshire Lead and Copper Mining Company (1836 - 1843): A prospectus for this company was issued in 1836 and the rules for the company were drawn up by George Cantrell, the agent of the previous company. A new agent, George Buckley of Ashover in Derbyshire, was appointed soon afterwards.

In 1836 the company had the foundations of the old steam engine house removed and an ore house was built here. The pumpway level was cleared out and prepared for use, and the sinking of a new shaft close to the old engine shaft was started. However, this shaft was abandoned in 1836-37 because of problems with excessive amounts of water entering it that prevented further sinking. Thus, operational plans were changed and instead a hydraulic water-pressure engine was installed at the pumpway horizon in the chamber adjacent to the old engine shaft. It was being erected at the time of Queen Victoria's coronation in June 1838 and was installed by an engineer called Joseph North. The water was brought, via a long sinuous launder, from the Lumb Pool situated west of Warslow Hall (Porter and Robey 2000, p. 113). This engine had a 12-inch piston and the beam attached to it that operated the pump rods had a six foot stroke and worked at 5-6 strokes per minute; on average it discharged 150 gallons per stroke into the pumpway. The engine shaft was deepened by 13 fathoms (78ft: 23.8m) and a new lift of pumps installed here.

In 1839, after the shaft sinking was completed, a horizontal passage known as the '*26 Fathom Leve*l' was driven for 70 fathoms (420ft: 128m). This was started from near the base of the shaft, but above a sump, and it ran under those parts of the pipeworking being mined at the time. Water from the pipeworkings flowed along it to the shaft base, from where this was pumped up the 26 fathoms (156ft: 47.5m) to the pumpway above. The 26 Fathom Level was also used as a haulage way to bring ore to the shaft, from where it was wound to surface; a horse-drawn winding whim somewhere near the collar was presumably used for this. The ore was processed on the same dressing floor as previously, located next to the shaft top. Waste water from the dressing was let into a culvert that ran down the slope and then under the road down to the river. The mine blacksmith was Sampson Kidd, but we don't know whether there was a smithy on site at this time or if his work was done off-site.

In 1842 a report on the mine was made to the Commission on Employment of Children, when George Buckley the agent said that 20 people were employed at the mine, including two boys under 18 who dressed the ore on a casual basis and were each paid 8 pence per day, both working under Abraham Thompson who supervised the dressing.

The mine closed in 1843, because of '*a disagreement between the proprietors*'. A plan of the 1860s marks '*Buckley's intended new engine shaft*' (Porter and Robey 1973, p. 172) and a decision not to sink this may have been at the heart of the dispute. This shaft is shown on the plan as directly above the north-eastern end of the abandoned engine chamber at river level. Presumably the two were designed to go together, indicating this underground feature may well have been started under Buckley's agency bur remained unfinished when the company closed; in contrast, there is no sign at surface that the shaft was ever started. When the mine

closed the hydraulic water pressure engine was dismantled and taken out by a Mr Frost from Fritchley in Derbyshire but the column of pump pipes was left in place.

In the 1840s a new road was constructed from Warslow to Brownslow Bridge to the south-west, which took a more direct route than the 1833 turnpike road between these two places; it is documented that they took stone to be used in making the new road from the Dale Mine tips; at this date the mine was inactive.

John Williams and Partners (1847 - 1852): Interest in Dale Mine was resurrected in late 1847 when Richard Ninnes working with John Williams, both from Cornwall, had the pumpway cleared out again and arranged contract bargains, presumably to test the viability of the mine. A formal lease between Sir John Crewe and John Williams and partners was signed in April 1848 by which time Ninnes was acting as the mine agent as well as being a partner in the venture.

Work at Dale Mine by these partners was probably small in scale, as mining was undertaken without the benefit of mechanised pumping plant. Depositions made for an 1871-72 court case stated that they had not worked below river level between 1847 and 1854.

In Dec. 1851 a report in the Mining Journal stated that Dale Mine '*holds out great promise to the adventurers and .... it is anticipated to erect sufficient machinery to prove this valuable speculation*'. However, by the next year no returns had yet been made and several partners withdrew.

James Pemberton, Thomas Lewis, William Johnson, Charles Lewis and Partners (1852 - 1857):

In 1852 several of the partners in the 1847-52 venture retired and new partners were found, primarily the four listed above, whilst Ninnes continued as a partner and agent. Mechanised pumping was not acquired straight away, presumably because of the expense, and it was not until 1854-55 that this happened; until then any mining undertaken must again have been above river level.

In 1853 they filled a shaft on '*Sawpit Vein*' that, if this is the vein running north-west/south-east to the north of the pipeworking as seems likely as a line of hillocks to the east side of the main mine hillock exists today, this would have been the aborted 1836 shaft sunk at point close to where the vein intersected the pipeworkings; it would have been in the way of the infrastructure planned for the site. In 1854 they started erecting an engine house for a small steam engine with a 19 inch cylinder next to the collar of the main engine shaft, located to its north side close to the site of the filled shaft. This engine had been bought second hand from a colliery at Hazelbarrow in the Goldsitch Moss area of upland coal mining in the Staffordshire part of the Peak District (Barnatt 2014, pp. 96-102). The engine had been used as a steam winder but was converted for operating pumps in the main engine shaft when it was brought to Dale Mine; it was put to work here in October 1855. Its pump rods were connected to flat rods below the pumpway level that led down the pipeworkings to the then sole of the mine; these rods were gradually extended and new pumps fitted as extraction went deeper, reaching at least 32 fathoms (192ft: 58.5m) below river level by 1857. A schematic architect's drawing of the Cornish-type engine house survives (Porter and Robey 2000, p. 128). This shows its chimney was attached to the back right-hand corner and the boiler house was built behind the engine house, protruding to the right side; the configuration of engine and boiler houses is confirmed for Dale Mine on an 1860s mine plan showing details of the *c.*

1857-59 period infrastructure (Porter and Robey 1973, p. 172). Given the constricted nature of flat land at the site, the coal yard presumably lay to the west side of the engine house at or near the shaft filled in 1853.

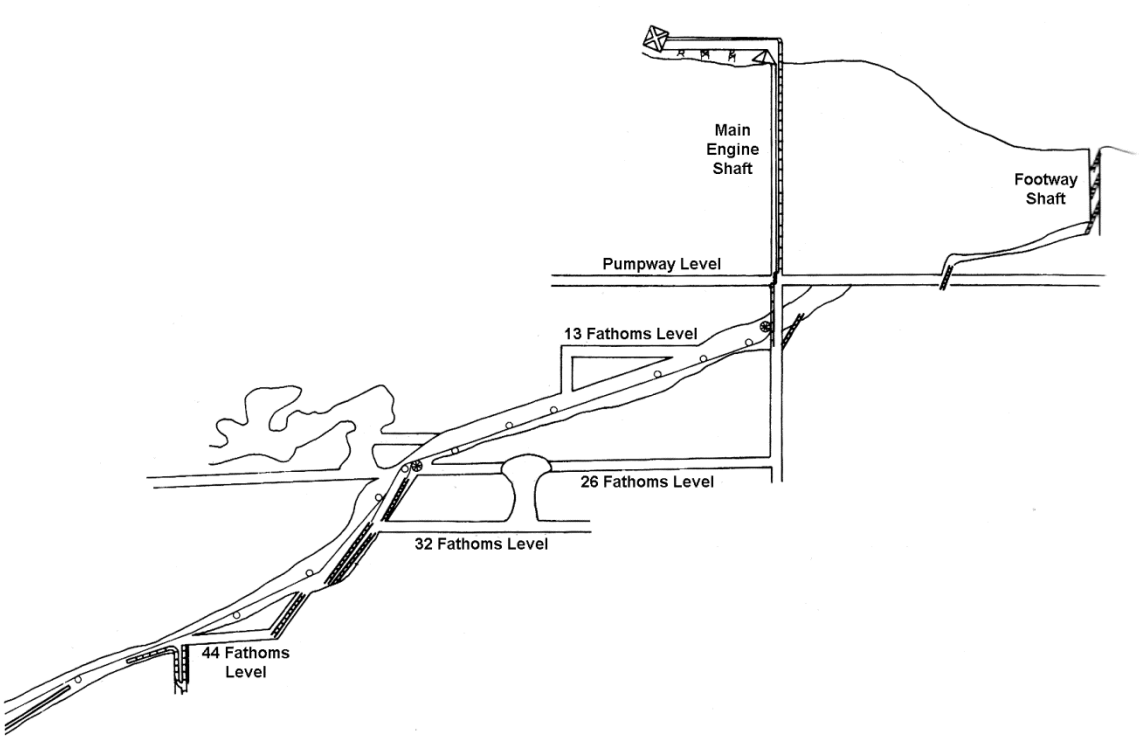

Figure 6: Schematic elevation of the underground workings at Dale Mine, taken from an undated drawing made in about 1860, showing active workings in the *c.* 1855-60 period, together with older workings, and the positions of pump rods, flat rods and ladders (after Porter and Robey 2000, p. 126).

The steam operated pumping engine allowed them to work at the old 26 fathom level that led from near the base of the engine shaft (156ft: 47.5m). They also went deeper in the pipe deposit, working from a level at 32 fathoms (192ft: 58.5m) and also mined above at a 20 fathom level (120ft: 36.5m) that was driven north-westwards during 1857. This may have been at '*No. 3 Lode*' in the main pipeworking where mining was started in October 1855. At the 26 fathom level a cross cut was driven westwards following a vein that was ten inches wide but because of poor ventilation a '*gate*' was driven back to the pipeworkings; this vein was probably a continuation of what was known as '*Johnson's Load*'. The 32 fathom level was the most productive, with this driven southwards from the main pipeworking to meet a winze being sunk from the 26 fathom level in an eight inch wide '*vein*' of lead; this area was stoped out. Water was a problem and a dam had to be erected in the 32 fathom level north of the new stope, made in order to hold back water coming from the main pipeworking, before extraction could be taken down below this horizon in 1857. Here the vein widened to 4 feet and was worked on tribute bargains. Elsewhere in the mineralised deposits, at the 20 fathom horizon, they trialled the '*Johnson Lode*', which crossed the main pipeworking on a south-east/north-west orientation. In 1856 they raised 98 tons of lead ore from Dale Mine as a whole, which sold for £1,900. While the prospects for the mine were said to be good, the sale of the ore raised did not match the expenses incurred to extract it.

Reports on Dale Mine were made from late 1855 in the Mining Journal, presumably reflecting the partners desire to raise further capital by forming a company that had more shareholders who could contribute to the expense of developing the mine; a prospectus was issued in 1856.

Melville Attwood (1854 - 1856): In the same period as just described, between 1854 and 1856, large amounts of zinc blende (zinc sulphide) were recovered from the Dale Mine tips by Melville Attwood; developments in smelting technology now allowed this previously discarded ore to be processed. Attwood, who ran the Ecton Mine Company of 1838-46 at Deep Ecton Mine across the river, concentrated on the lead and zinc ores rather than those of copper (Barnatt 2013a, pp. 229, 234). He processed the Ecton ores at Swainsley Stamps a short distance downriver, including much blende from the mine tips; in 1854 he turned his attention to Dale Mine as a further source of this previously discarded zinc ore.

Dale Mining Company Ltd (1857 - 1868): The prospectus for this company issued in 1856 stated that they intended to install a 35ft diameter breast-shot waterwheel of 6ft width to drain the mine. It does not seem to have ever been installed, for although there is a now part backfilled chamber at the pumpway horizon, as noted above, this unfinished chamber is more likely to date to the early 1840s.

The Dale Mining Company Ltd was registered in October 1857 and was set up by the 1852-57 group of shareholders detailed above, in order to finance pumping out the mine to greater depth. Initially £21,000 of capital was raised, with this later increased to £50,000. The old partners were stated to have already spent £6000 in developing the mine and they took shares to this value as compensation for their investment. At the outset the directors included James Pemberton, Thomas Lewis and William Johnson; Ninnes continued as agent, but Pemberton and Johnson retired as directors in 1858.

Activities at Dale Mine from October 1857 are again well documented in regular reports in the Mining Journal, with these made for the benefit of the shareholders, as was usual with limited liability mining companies at this time.

Aspects of the Company's activities at Dale under Ninnes were the subject of complaint by several of the shareholders in 1858-59, who suggested that Ninnes was guilty of fraud. It was reported by Ninnes in the Mining Journal that a rich ore deposit was discovered at the 37 fathom level in February 1858, saying that this was the richest discovery of ore in the area for fifty years and that '*the lodes are larger than at Ecton and in all probability will outrival Ecton*'. However, ore was not raised in quantity and in retrospect the shareholders recognised that this was a blatant exaggeration made to heighten interest in Dale Mine and attract further investment. Another matter of concern raised by shareholder was in regard to the purchase of New York Mine located *c.* 5 km to the west. This had lain idle since mining here had ceased and the engine had been offered for sale without result in 1853 and again in 1854. New York Mine and its engine were purchased by the previous Dale Mine partners in about 1855, with costs later passed on to the Dale Mine Company. There was much debate amongst shareholders in 1858-59 as to whether, through vague accounting and reporting to them, they had paid more for the steam engine than they had believed they had (for a detailed account see Porter and Robey 2000, pp. 122-24). Dissatisfaction with how the mine accounts were drawn up rumbled on into the 1860s.

An 1860s mine plan, showing details of the mine in *c.* 1857-59, shows that as well as the engine house and boiler house at the head of the engine shaft to its north side, there was also a '*smiths shop*' nearby to the east of the shaft and a '*wood shop*' between the two (Porter and Robey 1973, p. 172). To the south-west an un-named structure at the dressing floor may well be the 'ore bins' still surviving today. The plan marks the dressing floor to the south of the shaft indicating the lower dressing floor existed by this date; the upper dressing floor to the west of the engine shaft presumably was also still in use, now for preliminary preparation of the ores. This upper floor had been here since at least 1847 when Ninnes arrived at Dale and may well have been created much earlier, at the time when the Newcomen-type engine was installed. No details of the equipment used in the 1850s on the dressing floors are documented, but it is likely that they included hotches and buddles as was usual at larger mines at this time. The used water from the dressing floors from *c.* 1854 was taken through a '*small wooden box*' that acted as a catch pit before being culverted down the steep slope to the side valley from where it ran down to the Manifold. The dressing floors at the main site closed in 1863 after a new one was built alongside a new engine shaft to the north.

At Dale Mine a significant problem arose in March 1859, when the small 1854-55 pumping engine failed. A new lift of pump pipes had been installed between 37 fathoms and 43 fathoms to allow deeper mining and this caused the crank to break and the engine had to be stopped. The Company had no way of keeping the mine dry without installing a new engine with some urgency. One of the main tasks undertaken by the Company in 1859, now possible as financing was on a firmer footing, was the erection of a more powerful steam pumping engine. The steam engine at New York Mine was last worked at this mine in March 1859, when it was used to dewater the workings to remove the pitwork before the workings here were abandoned. The engine was ready for removal in April and within a few months it was installed and put to work at Dale Mine. The engine house had presumably been built in 1858 and/or early 1859, as a building of this size would have taken months to erect, and thus this work must have been started before the old engine failed; therefore installation was being planned anyway. The Dale Mine Company paid £2,600 to acquire the New York engine. It had a cylinder diameter of 40 inches (1.0m), with a 9ft (2.75m) stroke at the cylinder and a 7ft (2.15m) stroke in the shaft, which could work to a maximum of a little over ten strokes per minute (Porter and Robey 2000, p. 143). The pump rods were again connected to the flat rods going diagonally down in the pipeworkings.

At the time the new pumping engine was installed, the old steam engine was converted for use as a winding and crushing engine, with the ore wound up the main engine shaft from its base after ore had been brought from depth up to here using windlasses in the pipeworkings and in internal winzes between different levels.

With the new pumping engine in work it was now possible to mine the pipe deposit more efficiently. Before it was installed, they were already working at the 37 fathom (222ft: 67.5m) and 43 fathom (258ft: 78.5m) levels. After the larger engine was in place they were still working at these horizons, with the '*rich ore in barrowfull… in lumps the size of walnuts to 3-4cwt masses*' being extracted. Eventually they also went down to somewhat greater depths but it was not until 1863 when a new engine shaft was completed that the miners were able to work successfully as deep as 50 fathoms (300ft: 91.5m). Also a new deposit was found in 1861 between the 37 and 43 fathom levels. This became known as the '*New Pipe Vein*' and was eventually followed diagonally downwards, with yet another new lift of pumps attached to the flat rods.

While the ore output from the mine appears to have been low between 1857 and the installation of the new engine, by the end of 1859 lead ore had been raised in the last three months of the year that sold for £1,029 whilst the running costs had been only £850. In 1860 ore worth £3,340 had been raised and in 1861 the output was worth £4,107 (Porter and Robey 1974, p. 286). However, looked at in broader terms, these figures do not reflect the capital investment by the shareholders in the plant installed to make this possible, so even in these years they do not indicate a real profit was being made. In the second half of 1861 the situation was deteriorating. For while ore worth £1,336 was raised, the mine running costs were greater and there was an overall loss of £411. Ore output in 1862 was disappointing and worth only £836, whilst the figure for 1863 are not known. By 1864 things had picked up again, with the ore value for that year being £5,560, whilst that for 1865 was £3.500; in these two years significant amounts of zinc ore as well as lead ore were raised. However, from 1866 onwards the output of both dropped markedly.

As the pipe deposits went gradually deeper as they extended northwards it must have become clear to the Company management that a new shaft would be needed in this direction for ore raising and to supplement the pumping arrangements. This was proposed in the Company's June 1860 meeting. The shaft was to be 88 fathoms (528ft: 161m) deep, would cost about £1,000 and was to take nine to twelve months to complete. To finance this, the remaining 2,865 untaken shares, out of a total of 21,000, were to be offered for sale. Later, in 1863, the company created 5000 new shares to meet the ongoing and unanticipated costs of the new infrastructure. The shaft sinking actually took over two and a half years and the final depth was 105 fathoms from surface (630ft: 192m), with this linked to the main pipe deposit in November 1863. The shaft was 10ft by 6ft in compass (3.0x1.8m) and was divided into two compartments throughout its entire depth, with one for winding, the other for pump rods, pump pipes and a ladderway. Where it passed through unstable ground, at between 35 and 50 fathoms depth (210-300ft: 64-91m), timbering was needed. The pipeworkings were reached at 101 fathoms (606ft: 185m) from surface, with a sump of 4 fathoms (24ft: 7.5m) added below. It was noted by Ninnes in 1870 that the shaft was out of plumb by 38ft (11.5m), but whether this was the result of poor shaft sinking or the geological conditions encountered is not known.

An access roadway to the new shaft for transport of equipment was being made by April 1862. The 19 inch cylinder winding engine was moved and installed at the top of the new shaft and started work in June 1862; presumably they started building its engine house in late 1861 or early 1862 after the old engine house was blown up to provide the building stone. Soon after its installation, a '*large piston machine*' was added to the engine that was presumably for an air compressor to ventilate the shaft as it was being sunk. Water entering the shaft was brought up in buckets using a horse-drawn winding whim. By the beginning of 1863 the shaft had reached 70 fathoms (420ft: 128m) from surface and the water problem had increased to a point where they decided to use the 40 inch engine at the old engine shaft to pump it out. Flat rods at surface were taken to the new shaft and connected here to pump rods; a rise in the ground level over a length of 50 fathoms (300ft: 91m) was cut away to make this possible and elsewhere along their run they passed through three limestone quarries in the limeburning complex here and were place on trestles (Porter and Robey 1972, p. 103). Sinking, with three lifts of pumps, was recommenced by the end of March 1863. A crusher house that held a '*double rolled crusher*' was erected that was to be attached to the 19 inch engine, a new smithy was built, as was a carpenters shop, and a new flagged dressing floor was created; here there were '*hutches or jigging tubs*', '*buddles*' and '*catch pits*'. They used the catch pits to maximize ore recovery by dressing the fine fraction of the crushed ore.

While the new shaft was being sunk, with efforts concentrated here, ore production from the mine ceased in early 1862 and the old pipeworkings were allowed to flood to the 26 fathom (156ft: 47.5m) level. In 1863 these workings were pumped out again down to the 43 fathom (258ft: 78.5m) level in advance of recommencing mining. By this date the flat rods in the pipeworkings powered via the old engine shaft were operating 16 short lifts of pumps, with the rods at various angles, and the friction put on them led to several breakages and the new pumping arrangements were badly needed.

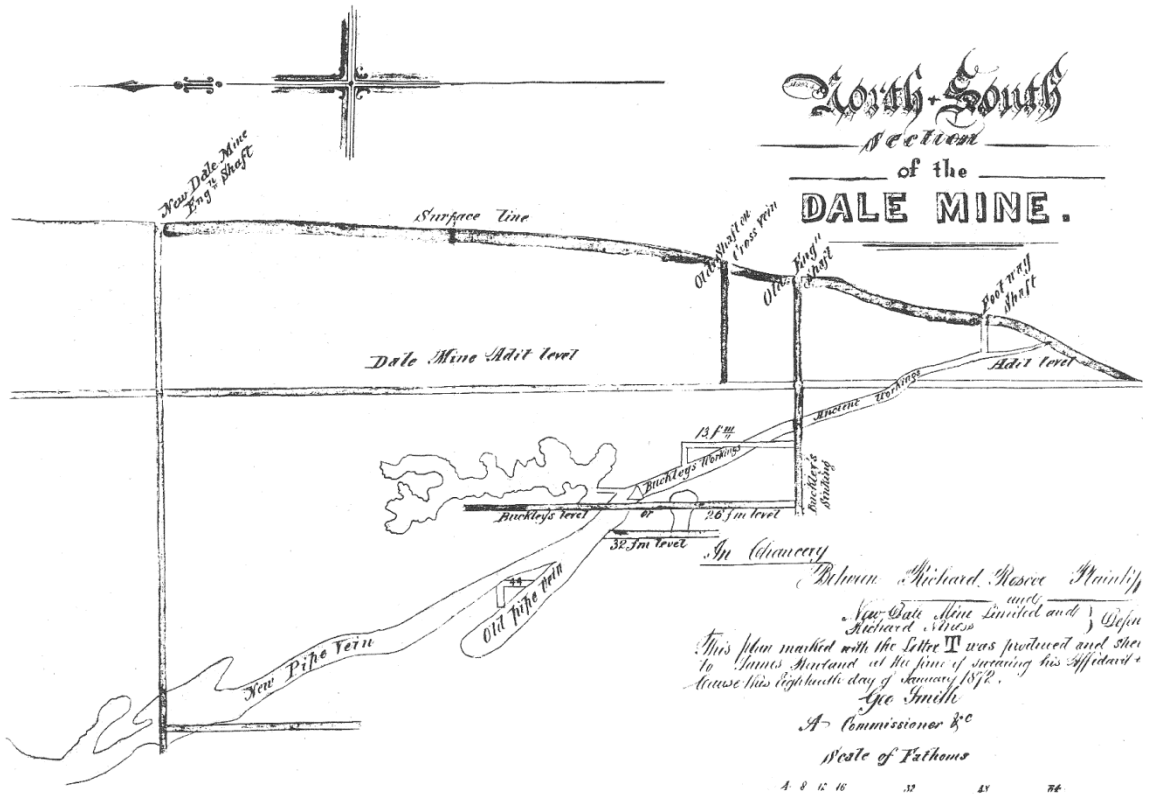

Figure 7: An 1872 elevation of the underground workings at Dale Mine drawn for the 1871-72 court case.

The new shaft, sunk from the high ground to the north of the old mine complex, entered the pipeworkings at about 50 fathoms (300ft: 91m) below river level in November 1863. Mining commenced in the pipe deposit down to this depth and the first 68 tons of ore was sold in March 1864. From this date forward, for 5-6 years, they recovered 40-60 tons of lead and 40-50 tons of zinc per month. By mid-1864 the mine was again in 'profit' and in 1864-66 the mine employed about 100 men. However, after that time the workforce was reduced by half as ore suitable for recovery from the pipe deposits lessened. From 1866 onwards output was usually poor.

In 1863-64 they drove a tramway level from above the sump in the base of the new shaft that ran southwards under the pipeworkings above. In 1864 they connected the ore tubs used here to the winding engine so that these did not need to be pushed by hand. The new workings accessed via the engine shaft finished in 1863 had ventilation problems and in 1864 they installed a waterblast in the new shaft to alleviate the problem, later in the year a winze sunk from the old workings down to the tramway also helped. At the end of 1864 they bought a new steam engine boiler to help with the workload required.

In 1864 they were recovering ore from the main pipeworking and in a vein or branch pipe deposit running parallel to it. During 1865 the pipeworkings became poorer as they went downwards and by the end of the year the complex series of workings had four active headings at various horizons. A plan dated *c.* 1865 shows that the workings eventually went down to about 25 fathoms (150ft: 45m) below the haulage level near the base of the new engine shaft and extended at least 75 fathoms (450ft: 137m) north of the shaft (Porter and Robey 1972, p. 103). Above, at '*Johnsons Load*', work was also being undertaken.

The last royalty payments to shareholders was made in January 1865 and henceforward the mine ran at a loss. The company was wound up in 1868, with the liquidator giving permission to register a new company.

New Dale Mining Company (1868 - 1873): This Company was registered in May 1868 and it purchased the lease, plant and equipment of the former operation. The initial capital raised was £5,000 but by 1871 this had risen to £20,000, with the shareholders paying 'calls' each year; the company never paid mining dividends from profits made. Reports in the Mining Journal were infrequent, as it was run as a 'costbook' company and thus they were not obliged to give reports here. Throughout the 1868-73 period ore output was only small (Porter and Robey 1974, p. 286).

The new company seem to have worked in various parts of the mineral deposits well above the sole of the mine. In 1868 they drove a cross cut at 75 fathoms down the shaft (thus at *c.* 24 fathoms (144ft: 44m) below river level) finding several veins but with none producing significant quantities of ore. A waterwheel of 18ft (5.5m) diameter and 5ft (1.5m) width, was erected underground at this horizon in 1870, to be used to blow air because of poor ventilation here. In 1872-73 they were driving a level both north and south at this same horizon, with a raise put up from this for 5 fathoms (30ft: 9m). Deeper in the mine, in 1870 a tramway level at the 44 fathom (264ft: 80.5m) horizon was driven southwards from the new shaft that ran on timbers across the old workings in the pipe deposit. '*Johnsons Load*' was reached by a cross cut at this horizon and was producing ore in this period.

In about 1870 the steam engine was pumping water into the pumpway at an average rate of 84,852 gallons every twelve hours, with an additional 30,267 gallons taken up to the new dressing floor for use here. After use it was passed through three catch pits to reduce the pollution in the water before being culverted and taken to the roadside ditch that led to the river at the bridge over the Manifold near the entrance to the pumpway. Somewhere nearby there was an '*office*', which presumably was associated with the mine, as well as at least two houses; these have all disappeared. The Ordnance Survey 25 inch to a mile map of the area, surveyed in 1878 and published in the next year, shows a rectangular building and yard next to the river immediately north of the platform over the pumpway drain.

In 1871 the New Dale Mine Company and Richard Ninnes the agent were taken to court by Richard Roscoe the owner of Swainsley Hall, which is situated a short distance down the Manifold valley (Porter and Robey 2000, pp. 231-34). Roscoe had taken the fishing rights on the east bank from the Duke of Devonshire in 1868 and sued because he believed the mine was polluting the river with water from its dressing floor. The case went in favour of the mine, but this was appealed and the mine proprietors were advised they could not prove their right to put water into the river and they capitulated. Starting in early 1873 the Mine proprietors constructed new filter beds and catch pits to prevent polluted water from the dressing floor from reaching the River Manifold.

The mine closed in late 1873, presumably in part as a result of the litigation and difficulties in preventing pollution entering the river but also, more significantly, because by then ore output was poor.

Historic Use of the Dale Mine Site

The surface survey at Dale Mine shows that not only are there surviving features related to the mining here, but also that stone quarrying and medieval cultivation have left an archaeological footprint on the landscape.

Metal Mining: The mining is the main focus of this paper and only specific aspects of the evidence are summarised here, given as a preliminary to the section below on 'Interpreting Dale Mine' where detail is given. A strong contrast exists between evidence for shallow working, some of which at least is likely to be early, and infrastructure such as access roadways, a reservoir, buildings and leats, associated with deep mining at the pipe deposit below the river horizon. The former are scattered across the site in a south-east/north-west band where miners were working vein and pipe deposits, whereas the main engine shaft that went to pipeworkings at depth, lies at the centre of site. It is surrounded by platforms for buildings and ore dressing, including one remaining ruined stone structure and a large waste hillock; smaller earlier feature have presumably been subsumed under the main hillock. The entrance to the pumpway lies to the far south-east. The Footway Shaft above, and probably another on what is thought to be '*Sawpit Vein*' to the north of the first, are the only identified early features where horse-drawn winding whims were used for ore extraction before the main engine shaft was sunk.

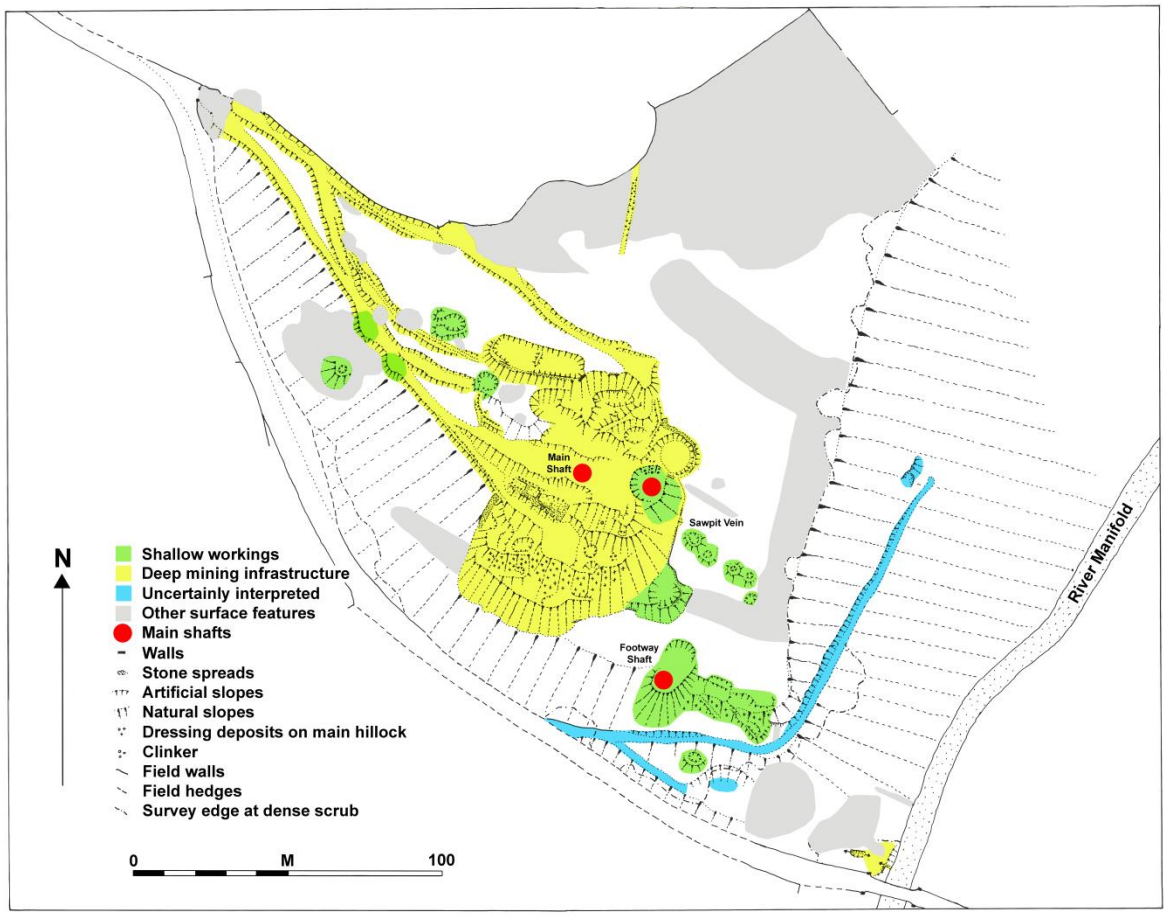

Figure 8: Metal mining surface remains at Dale Mine.

One important set of relationships at Dale Mine clarified by the surveys is the correlation between the surface remains and the accessible underground workings. This shows that infill from above at the southern end of the top-level pipeworking accessed from underground is at the base of the Footway Shaft. Also, the abandoned engine chamber has no sign of an associated shaft at surface. The positions of the now-inaccessible pipeworking running south-eastwards to surface, and the now-flooded workings below river level running north-west are estimated from schematic 19th century mine plans and elevations (Porter and Robey 1972, p. 103; 1973, pp. 172, 173; 2000, pp. 126, 127). This clarifies where the upper pipeworkings are likely to have first been found at surface; that an unfinished 1836 shaft is likely to have been close to where what is thought to have been '*Sawpit Vein*' and the main pipeworkings intersected; and that the deviation westwards of the pumpway extension may have been designed to find the extension northwards of '*Johnsons Load*'; the level through '*The Lumb*' may be a natural feature developed on this vein.

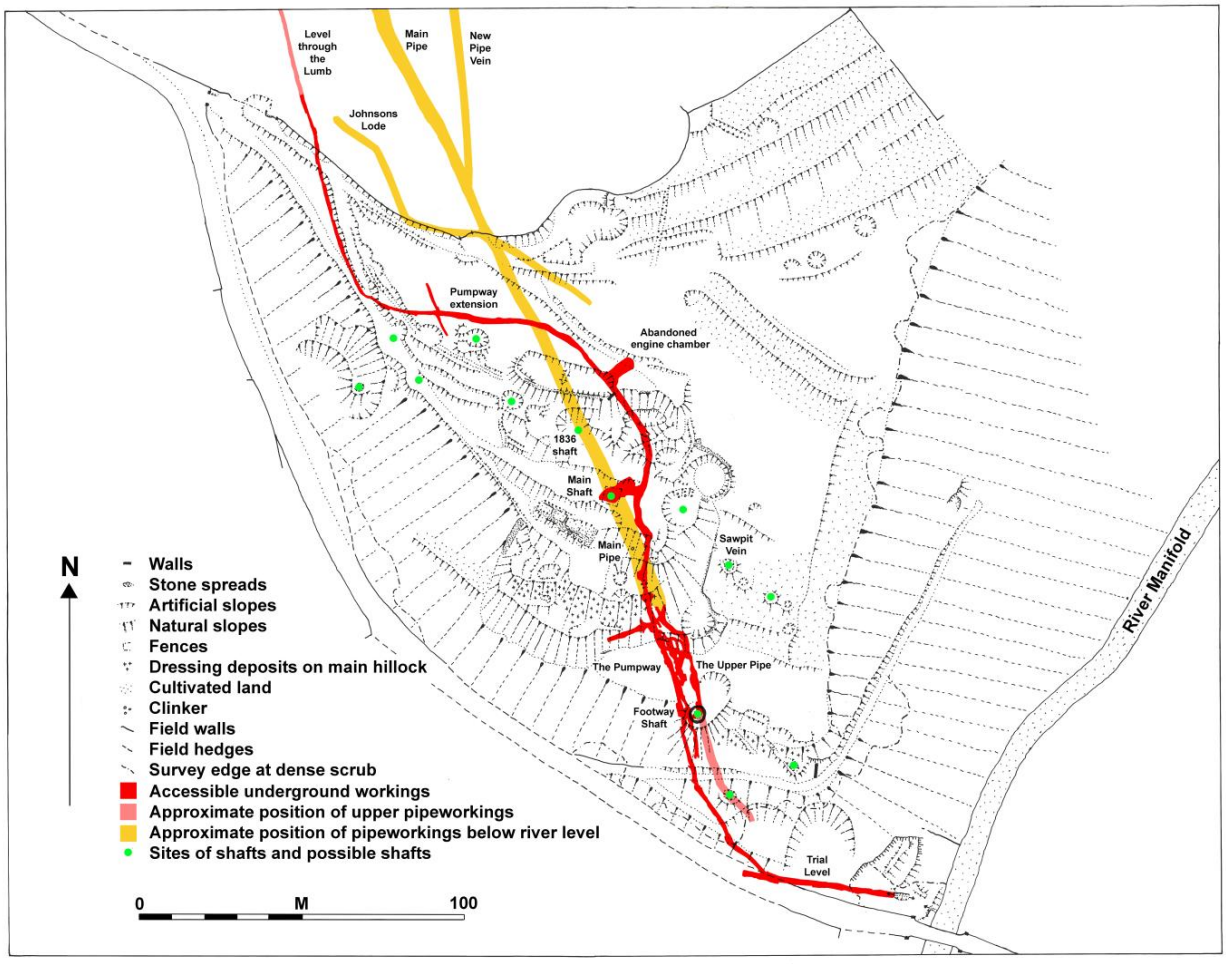

Figure 9: The relationship between the surface mining remains at Dale Mine and known and now-inaccessible underground workings; the last are shown in simplified form, for not enough detail was recorded on historic mine plans to do otherwise.

Stone Quarrying: Limestone extraction took place on the site both to the north and south of the quarry dug to build the adjacent engine houses at the main engine shaft of Dale Mine. To the north was a large limeburning complex, only the southern fringe of which lies within the area surveyed. Beyond the survey boundary to the north there are the ruins of at least two commercial-type limekilns, each with a single pot, surrounded by relatively shallow quarries on their upslope sides. The date of these kilns has not been identified from historical sources, but by comparison with other sites in the region, they are likely to be 18th or early-19th century in date (Barnatt and Dickson 2004, pp. 181-99).

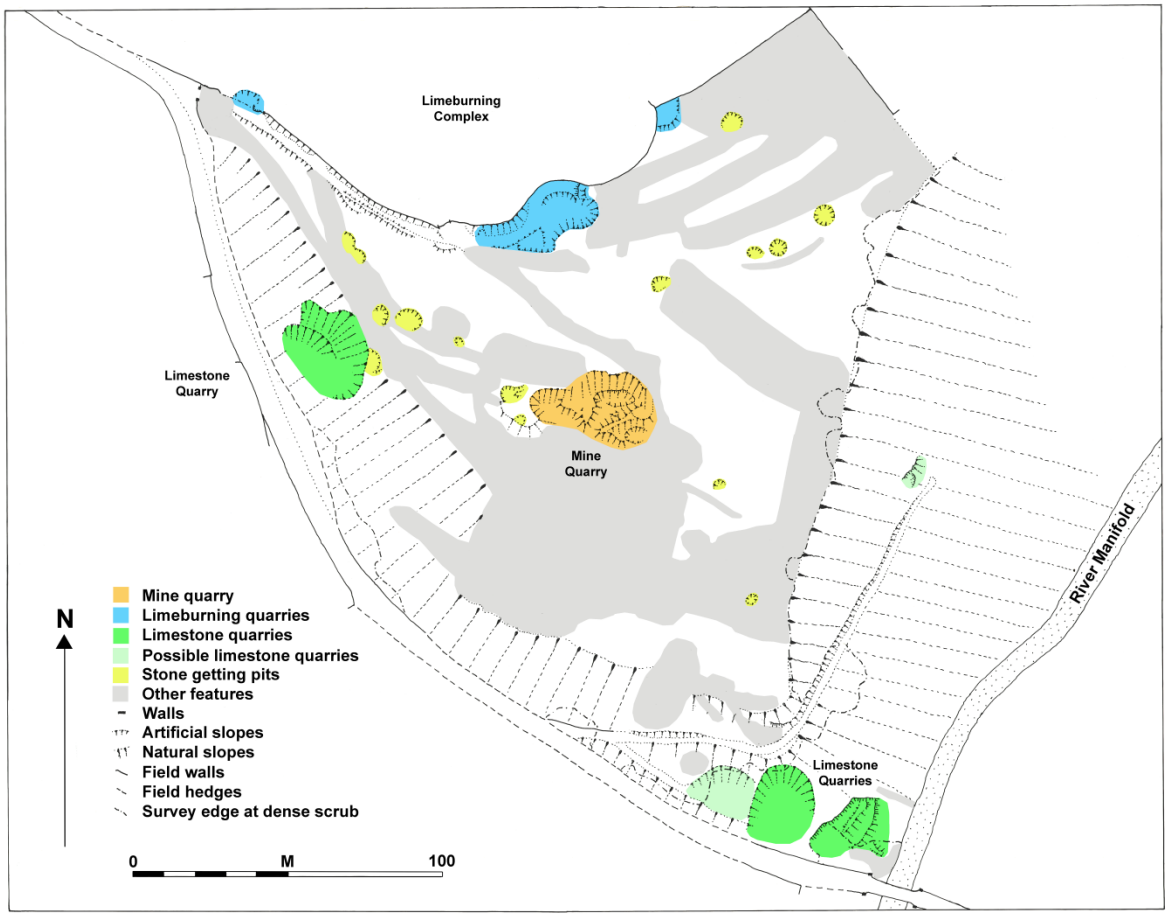

Figure 10: Stone quarrying at the Dale Mine site.

The quarry to the west side of the survey area, and two or possibly three conjoined examples to the south-east, have no associated limekilns. Again no light has been thrown on the date of these stone quarries from historical sources, but they are likely to of 18th or 19th century date. If those to the south-east are 18th century in date, as seems likely given that the mine pumpway appears to post-date the south-easternmost quarry here, then it may be that the Dale Mine pipeworkings were first discovered at surface during stone extraction operations. In the cases of all the stone quarries except the south-easternmost, given the likely character of the material removed that may well have been thinly bedded stone, it may be that they were dug to provide construction material for the adjacent road; this is part of a turnpike road authorised in 1770 and presumably built soon afterwards.

In addition, there is a scattering of 12-15 small stone getting pits across the site. Some of these to the north-west were perhaps dug in association with the construction of mine structures, while others may well have been dug for nearby drystone walls or other purposes.

Medieval Cultivation: Much of the site, with the exception of the steep daleside, has earthworks that show medieval cultivation took place here; this takes the form of long cultivation strips defined by lynchets. These are likely to belong to one of the open fields of Warslow, created in the centuries immediately prior to the mid-14th century when the local population was at its highest, before decline at the time of the Black Death.

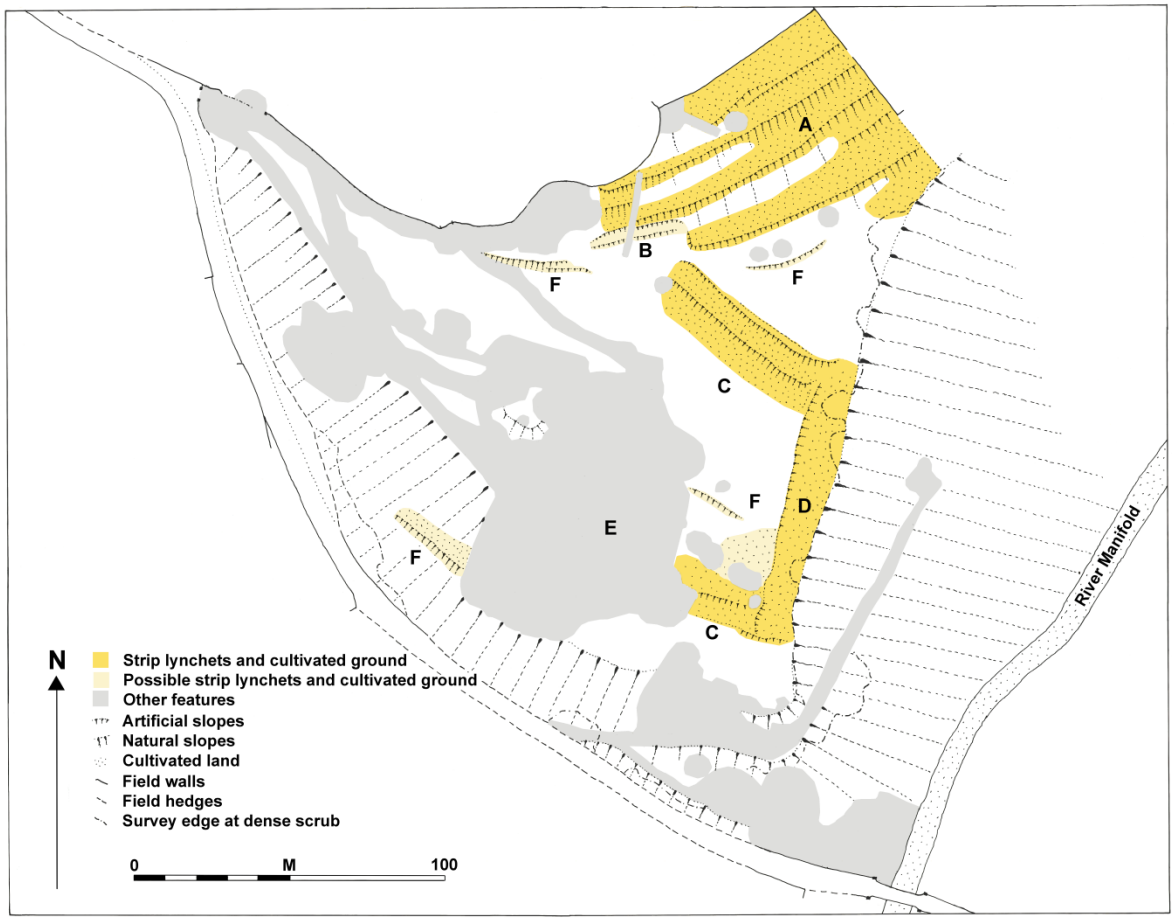

Figure 11: Medieval cultivation at the Dale Mine site (for A-F see text).

The strip lynchets are found in two blocks. To the north-east there are several parallel cultivation strips running with the contour (Fig. 11: A). One particularly narrow terrace may be an access roadway rather than a cultivation strip (Fig. 11: B). South of these, further down the slope on the spur between the steep valley side running down to the Manifold and the other steep slope that descends to the side valley, there are several parallel strips (Fig. 11: C) at a different angle to the first group, ending to the south-east at a single strip at right-angles immediately above the steep daleside (Fig. 11: D). Only parts of these lower parallel strips survive, while to the west they may well have been buried by the main Dale Mine hillock (Fig. 11: E). Other features are uncertainly or in one case unlikely to be interpreted as associated with medieval cultivation (Fig. 11: F).

Not all the land between the lynchets in both sets was cultivated, with some linear areas left, presumably because they were too steep or otherwise unsuitable. In the north-eastern block, where the ground became steeper to the south-west the strips have uncultivated ground between them. In the south-eastern block, while their common orientation shows that strips were planned across this whole area of ground, only selected parcels were cultivated, while the rest of the ground was steeper or more uneven and strips marked out here were probably never utilised.

The two main cultivated areas use at Dale Mine were not ideally suited for this purpose in terms of topography, but because the bedrock is limestone the soils would have been relatively fertile if only thin; their use shows how land-hungry the medieval people of Warslow were before the Black Death; they cultivated every small area where this was viable.

Interpreting Dale Mine

Introduction: This section gives an interpretation of Dale Mine that assimilates the archaeological evidence at surface and underground with the surviving historical documentation.

The nature of the pipe deposit mineralisation, which descends NNW to well below river level presented challenges to achieving profitable extraction. One of the key factors in understanding Dale Mine is the number of relatively short-lived mining companies who operated there, each with its own ways of doing things and different approaches to making the mining here work.

When the historical documentation is set against the character of the surviving remains, this shows that sometimes both fit comfortably together but in other cases the latter tell of other activity that went undocumented or force revision of what we thought we knew from the surviving documents. The mining features at surface and underground are discussed below in turn, followed by more specific sections on engines and ore dressing, and finishing with an overview.

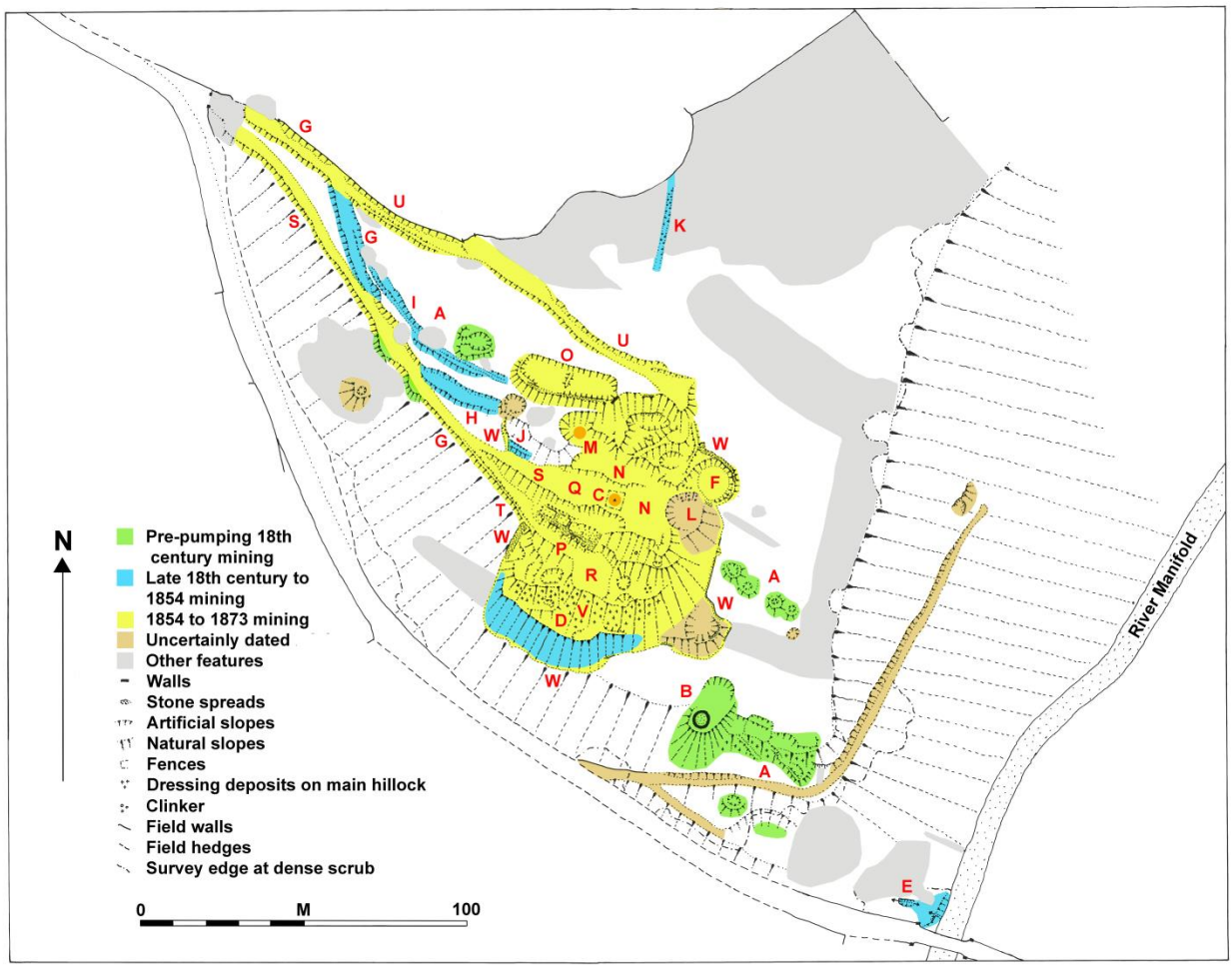

Figure 12: Mining through time at Dale Mine, showing the three main dating phases the surface remains fall within, with earlier features not shown when overlain by later ones or where they remained in use (for A-W see text).

Phases of Development at Surface: As seen in the previous section on 'Historic Use of the Dale Mine Site', a contrast exists between evidence for shallow mining and infrastructure for deep mining below river level. Phases of mining under different companies are explored below in terms of recognised surface features.

Figure 12 depicts three main phases of development identified; however where features continued in use from one phase to another, only their last phase of use is depicted; for earlier use see the text below.

Early Workings - At surface there are several shallow shafts, visible today as hollows at the centre of small waste heaps (Fig. 12: A). Some or all of these shallow workings may well be of 18th century date, developed before mining concentrated in the main pipe deposit below river level, a venture that demanded significant investment in infrastructure before this became possible. This said, whenever new discoveries of potentially viable mineral deposits were made, irrespective of date, these would have been explored, so some of the surface remains may relate to later activity.

Plate 36: A hollow and surrounding hillock at the site of a shallow shaft to the north-west of the reservoir at the main mine complex.

The main focal point of 18th century activity at the pipe deposit was at what later became known the Footway Shaft (Fig. 12: B). Here a gin circle platform and nearby ore dressing deposits show that ore-rich material was wound to surface from the pipeworkings above river level and processed here. The exact location of the outcrop of the main pipe deposit mineralisation is now not clear but must have been somewhere south-east of the Footway Shaft. The most likely location is in the deep scoop interpreted as a possible quarry with a small shaft hillock on the slope just above. Another shaft with associated gin circle, on a vein to the north rather than the pipeworkings, may be equally early but this interpretation is not certain (see below; Fig. 12: F, L).

Plate 37: The walled Footway Shaft on top of a hillock, with its gin circle platform to the right terraced into the slope.

Plate 38: This deep overgrown hollow on the daleside south-east of Footway Shaft, perhaps quarried, may be where the main Dale Mine pipe deposit was first found. In the foreground there is a small shaft hillock that may well be sunk onto the shallow pipeworkings here.

Mining from the late 18th century to 1854 - Radical changes in the mining infrastructure came in the late 18th century or possibly early 19th century, implemented by the Dale Mine Company (*c.* 1790s - 1810s). A deep engine shaft was sunk to below river level from sloping ground high on the valley side (Fig. 12: C). A hillock was created on the downslope side (Fig. 12: D). This was presumably smaller than that seen today, which has been added to and modified by robbing during subsequent mining episodes, although much of the limestone at its buried core and downslope side will derive from the shaft sinking. A Newcomen-type pumping engine was installed next to the shaft collar. While nothing remains above ground of the engine house, this is presumed to have probably stood immediately to the north, or possibly to the east, of the shaft; later activity here has masked the evidence. The engine bought water up to a pumpway that came to surface at the base of the steep daleside close to the river (Fig. 12: E). They must have used a horse gin for bringing ore to the surface and this would have been located somewhere close to the main engine shaft collar and it may well be that the extant gin circle east of here marks its site (Fig. 12: F); this is likely to have also been used earlier (see 'Horse-Drawn Winding Whims' below). Alternatively, the Dale Mine Company horse gin may have been nearer to the shaft, on the platform east of the shaft where later a smithy and then a Cornish-type engine house stood in the 1850s.

The earliest access roadway network to the mine may well have also been added in the 1790s-1810s period, comprising a roadway leading to the shaft and dressing floors (Fig. 12: G), with a branch leading to above the Newcomen-type engine house, perhaps used for bringing in the engine and later its coal (Fig. 12: H); parts of the first route continued to be used through much of the life of the mine. There are traces on the ground of a small leat (Fig. 12: I) and a possible launder terrace below (Fig. 12: J) that predate developments to water supply that came in the late 1830s. These would have supplied water to the dressing floor immediately to the west of the main engine shaft, which was probably first established as the time the shaft and its Newcomen-type engine were completed.

Nothing can be identified at surface that certainly relates to the small scale activities of the Warslow Mineral Company (1823 - *c.* 1830). We know they had a horse gin drawing water, presumably from the main engine shaft (Fig. 12: C); as with that in use in the 1790s to 1810s, this is likely to have been sited at the gin circle east of here (Fig. 12: F), or possibly closer to the shaft on its east side.

Further changes to how the mine was worked came with the setting up of The North Staffordshire Lead and Copper Mining Company (1836-1843). The key change revolved around the installation of an underground hydraulic water pressure engine in *c.* 1838 and this is discussed in the section below on underground development. The probable course of its water supply leat at surface, which fed pipes that ran down the main engine shaft (Fig. 12: C) from surface to the engine, can still be traced in part (Fig. 12: K). The ore house that they built at the site of the Newcomen-type engine house next to the engine shaft cannot now be seen at surface due to later structures having been built here. They were bringing ore up the main shaft, presumably using a horse-drawn winding whim and it may well be that the gin circle east of here was used (Fig. 12: F); although the possibility that it stood immediately east of the shaft cannot be discounted. When the company was first established they started sinking a new engine shaft but this was aborted due to problems with water. Its exact site is uncertain but it must have been relatively close to the pre-existing engine shaft (Fig. 12: C) that was eventually used with the underground engine, no surface remains on the line of the pipe deposit well to the north-west from here have been found that are likely candidates. While it is tempting to locate the aborted shaft at the hollow on top of a hillock (Fig. 12: L)

next to the gin circle (Fig 12: F), as this is the only other shaft with surface evidence, there seems no good reason why a shaft should would have been sunk here at this date; this location gained no advantage over the pre-existing engine shaft in terms of accessing the pipeworkings at greater depth that still remained to be mined and the shaft at Feature L is more likely to be earlier in date. Thus, more probably, the 1836 shaft is likely to have been in the quarry to the north of the shaft, perhaps to its west side (Fig. 12: M). Its collar would have been lost when stone was quarried for engine houses erected in the 1850s. It may well be that this shaft is the one documented on '*Sawpit Vein*', which was filled in 1853 a few months before they started building the first Cornish-type engine house. The postulated position in the quarry as given in Figure 12 is consistent with an '*Old Shaft on Cross Vein*' shown on a mine elevation drawn in 1872 (Figure 7 above; Porter and Robey 2000, p. 127).

Nothing at surface of the work of John Williams and Partners (*c.* 1847- 52), which was probably small in scale, has been identified. The same applies for the early work of James Pemberton, Thomas Lewis, William Johnson, Charles Lewis and Partners (1852 - 1857).

Hillock Robbing in 1854-56 - Melville Attwood was involved at Dale Mine in 1854-56 when he reworked the main hillock for zinc ore that had previously been discarded. Before this time zinc blende had been difficult to smelt, but advances in smelting techniques made this possible. The heavily cratered top of the main mine hillock (Fig. 12: D) may well largely date to this episode of reworking, although an earlier episode of hillock robbing for roadbuilding is also documented for 1840. The core of the hillock is earlier and primarily comprises limestone from the shaft sinking. This would have been subsequently overlain by waste material derived from ore dressing, much of which would have come from mining activities in the *c.*1790s-1810s and 1836-43 periods. It was this material that was targeted by Attwood and he may have reworked much of this, removing anything that was potentially zinc-rich. This left a steep step down immediately south of the main engine shaft (Fig. 12: C) with an irregularly shelving surface below; only the bottom part of the hillock with its steep slope was not touched. Subsequent to the activity of Attwood, further dressing material must have been added to the hillock during the 1855-1863 period; this is returned to below.

Mining from 1854 to 1873 - What we see today at the core part of the surface remains at Dale Mine reflects how they left the mine upon abandonment, the main parts of which date from the second half of the 1850s when the partners who set up the Dale Mining Company Ltd. were active; these are superimposed on the palimpsest of the earlier features discussed above.

In the mid- to late 1850s there were two engine houses placed next to the main engine shaft to its north and east sides (Fig. 12: N); a reservoir was built above (Fig. 12: O). A smithy and a carpenters workshop also stood near the engine shaft to its east side, as did 'ore bins' (Fig. 12: P) located below an upper dressing floor to the west side of the shaft (Fig. 12: Q). There was also a lower dressing floor near to the 'ore bins' (Fig. 12: R). Other than the 'ore bins', the 1850s buildings have been subsequently demolished and all that remains are the two platforms where they stood (Fig. 12: N). The access roadway network was also rationalised, now with a straight roadway giving access to the upper dressing floor, shaft and engine houses (Fig. 12: S), with a branch down to the 'ore bins' and lower dressing floor below (Fig. 12: T). Another roadway, possibly of this date, went to a point above the engine houses that was perhaps used for bringing in coal (Fig. 12: U).

In 1854-55 an Cornish-type engine house for a small pumping engine next to the main engine shaft, erected to its north side, was built by the 1852-57 partners (Fig. 12: N). In 1859 this

was converted for use as a winding and ore crushing engine by the Dale Mining Company Ltd. (1857-68), when a larger Cornish-type pumping engine was installed in a new house nearby to the east of the shaft. Both engine houses would presumably have attached boiler houses, unless the earlier boiler house was enlarged to power both engines.

Plate 39: The core area of the site, with the main engine shaft site near the top with longer grass within its rectangular fence. Below are the 'ore bins' and the main hillock, with the earlier Footway Shaft to the bottom right (Photograph: Peter Neville).

While we know that in the later 1850s they continued to use the pre-existing dressing floors west of the engine shaft, their size may well have been reduced by the hillock robbing by Attwood in 1854-56. This upper dressing floor may well have been used in the later 1850s for initial ore preparation, primarily its crushing ready for concentration; from 1859 the ore crushing here was mechanised with power provided by the northern engine. This reduction in size of the floor may well have prompted the building of the 'ore bins' directly below (Fig. 12: P), to be used for washing and storage of ore ready for further processing. A lower dressing floor adjacent (Fig. 12: R), built on a terrace almost certainly created during Attwood's activity, may well have been where the crushed and cleaned ore from the bins was buddled. Immediately below these features the hillock has distinctive dressing waste that may well have been dumped during ore preparation activity in the later 1850s and early 1860s (Fig. 12: V). At some point relatively late in the mine's history a belland yard wall was built around much of the core site (Fig. 12: W).

Until 1859 they would have needed a horse-powered whim for bringing up ore. This may well have been sited at the gin circle to the east (Fig. 12: F), argued above to have been

created in the 18th century; the distance from the shaft, which is unusual, is explained by the adoption of a pre-existing feature.

Plate 40: The main hillock below the lower dressing floor, with limestone rubble below (left and foreground), with its robbed top overlain by ore dressing waste (right).

The 1854-55 engine house north of the long used engine shaft was blown up in the early 1860s to provide building stone for the engine's new home at the new engine shaft well to the north-west. The smithy and possibly the carpenters shop near the main engine shaft (Fig. 12: N) were removed slightly earlier to make room for the 1859 engine house. The date that these two buildings were erected is unclear but they may well have been added in the mid-1850s when the new mine infrastructure was being redeveloped. Where smithing and carpentry work was done from 1859 into the early 1860s is not known; perhaps new buildings were attached to the new engine house to be used for these purposes.

No trace of modification to the land surface for the flat rods to the new engine shaft of 1861-63, running north-westwards from the 1859 pumping engine house at the old engine shaft (Fig. 12: C), have been found within the 2018 survey area; here these must have been set above ground, following the slope diagonally upwards, without this being necessary.

Presumably very little at the main Dale Mine site surveyed in 2018 relates to mining activity after 1863, by which date the Dale Mine Company had shifted their extraction focus to their new engine shaft well to the north-west; the New Dale Mining Company (1868-73) also worked here. However, it may be that the eastern half of the access roadway (Fig 12: U) above the steam engines at the old engine shaft is part of the access route built in 1864 to take the winding and crushing engine to its new site. The demolition of the 1859 engine house

took place soon after mining at Dale Mine ceased in 1873; it was not here by 1878 when the first 25 inch to a mile Ordnance Survey map was surveyed. Similarly, what was presumably an office for the mine located next to the river near the pumpway entrance, which was standing in 1870, had gone before the end of the century; we know nothing of when it was built.

Phases of Development Underground: All of the passages still accessible today have been created using gunpowder to break rock and their shothole scars litter the walls and roofs; these are of 18th and 19th century type used with gunpowder that are consistent with the date of the workings as established from historical records.

Early Workings - The mineralised pipe deposit at Dale Mine must have been first discovered at surface part way down the daleside; the location of this is unclear except in general terms as these workings are now inaccessible. This ore deposit was perhaps found in the early- to mid-18th century during stone quarrying operations.

The earliest accessible workings are the small pipeworkings at and above the pumpway that were originally accessed from what in the 19th century later became known as the '*Footway Shaft*'. This shaft probably has 18th century origins and was initially used to wind ore out of the workings, as indicated by the gin circle platform at its top, sunk before mining followed the pipe deposit deeper, going beneath river level, and thus they needed pumping to be worked. Later, after new pumping and ore removal infrastructure was put in place, the old shaft was converted to a footway that allowed miners to access the deeper workings via a series of ladders, when coming from the main mine complex at surface nearby to the north-west. Nineteenth century elevations of the workings show that the shaft was roughly 10 fathoms (60ft: 18.5m) deep (Figures 6 and 7 above; Porter and Robey 2000, pp 126-27).

It may well be that the filled shaft with adjacent gin circle at the eastern side of the later main mine complex is of comparable date to the initial use of the Footway Shaft. This is on what is thought to be '*Sawpit Vein*' and would have been used to bring ore up from now-inaccessible underground workings here. The shaft hollow lies close to the 1850s carpenters shop and it may be that it was used as a sawpit, thus giving the name for the vein used in the 1850s; its original name is not known.

Another early feature is the accessible trial level near river level, later utilised when the pumpway was created. This trial was driven with powder through limestone, presumably created to search for mineral deposits; it was not successful. However, around the time it was driven we know that there may well have been several other shallow workings being undertaken across the daleside above that followed ore-bearing ground, mostly presumably not rich in ore; at least one of these must have led eventually to the main pipe deposit that became a large producer at depth.

The Main Engine Shaft - Later, at the time the Dale Mine Company was active, in order to achieve easier access to the main pipe deposit that was gradually sinking deeper below river level in a north-westerly direction, a new engine shaft was sunk to the north-west of the Footway Shaft at a point further up the daleside. It remained the main engine shaft at the mine until the early 1860s and was kept open for pumping until the mine closed in 1873. This shaft had the advantage that it facilitated more efficient pumping and the winding of ore to surface by using a single vertical shaft that led straight down to the pipe deposit below river level. The disadvantage of having this new shaft, as it was further up the hill, was that it

had to be sunk deeper than it would have been if located lower down the slope. This engine shaft may well have been sunk in conjunction with the installation of a Newcomen-type steam-powered pumping engine at its top. The exact date of its erection at Dale Mine is not known. The first record of the engine is 1807-11 when it was already in use and it may have already been on site for some time; it was disused by 1823. The setting up of this new infrastructure may well have taken place sometime in the last two decades of the 18th century, at a time when steam engines were being erected in small number at metal mines spread widely across the Peak District, whereas earlier they had largely concentrated in the south-eastern part of the lead orefield where there were rich but waterlogged ore deposits that could not be worked without mechanised pumping (Barnatt 2018, pp. 78-88). That a haystack boiler, presumably for the Newcomen-type engine, was sold in about 1830 is another indicator of an 18th century date, for steam engines had often gone over to using waggon boilers by the early 19th century.

Mid-nineteenth century elevations of the workings show that the collar of the main engine shaft was at roughly 26 fathoms (156ft: 47.5m) above the floor of the pumpway (Figures 6 and 7 above; Porter and Robey 2000, pp 126-27). This shaft continued down for 13 fathoms (78ft: 23m) to a level and went through the pipeworkings at between about 4 and 8 fathoms (24-48ft; 7.5-14.5m) below the pumpway horizon; water was brought up to the pumpway that let it out into the river. This intersection was well above the depth that the mining finally achieved as the pipe deposits were followed ever downwards to the north. In 1839 the shaft was deepened by the North Staffordshire Lead and Copper Mining Company to well below the pipeworkings. From this date water was brought to the shaft bottom, via a level at 26 fathom (156ft; 47.5m) below the pumpway horizon, with the shaft sunk to this depth in order to allow mining to take place to the north in the descending pipeworkings. At this date the shaft had pump rods that came to its base and pump pipes brought the water up to the pumpway, while ore was brought to surface. In the mid-1850s the bottom section of pump rods were taken out, by the mining partners that went on to form the Dale Mining company Ltd in 1857, and connected to flat rods at a point where the pipe deposit was earlier intersected below the pumpway horizon (see Fig. 6). These now went down the pipeworkings, and below the 26 fathom level they were fixed to pumps connected to pump pipes, with these going to the sole of mining operations in order to drain this; they were extended through time as the mining went ever deeper. The water and ore were brought up the pipeworkings to the 26 fathom level, from where they continued to be brought up from the shaft bottom.

The Pumpway - The creation of this may well have been undertaken when the Newcomen-type pumping engine was installed by the Dale Mine Company, probably in the late 18th century or possibly in the early 19th century. It was needed to bring out the water pumped from depth and using this was the most cost-effective way of doing it; to take the water to the dale top would have been more costly both in terms of the need for a larger engine and the fuel to operate it. Alternatively, it could be postulated the pumpway passage is somewhat earlier, initially functioning as a sough driven to drain the workings above, with it later adapted to function as a pumpway. However, the small pipeworkings here could have easily have been dewatered using hand pumps and thus this interpretation seems far less likely.

When the Warslow Mineral Company was set up in 1823, if they did any work other than their failed attempt to drain the mine, it seems they must have largely worked above river level, and also perhaps in the pipe deposit at relatively shallow depth below river that could be kept dry using hand pumps. They demolished the old engine soon after they started their

operations and no evidence has survived to indicate they installed a new pumping engine. One possibility is that they extended the pumpway level for some distance beyond the location of the main engine shaft in search of more ore deposits but, while this extension certainly happened, this is more likely to have been in the late 1830s to early 1850s (see below).

Plate 41: Inside the Dale Mine pumpway; in the 19th century when the pumps were operating there would have been significantly more water than there is today (Photograph: Mat and Niki Adlam Stiles).

The North Staffordshire Lead and Copper Mining Company, set up in 1836, adopted a radically different approach to dewatering the mine. They started their activities by attempting to sink a new engine shaft, thought to have been a short distance north-west of the old one. This was presumably designed to hit the pipeworkings at greater depth than the shaft previously used for pumping in conjunction with the Newcomen-type engine. However, this new shaft was abandoned because of problems encountered with water during the sinking. They then went back to using the old engine shaft, which has been argued above to probably be of late-18th century or possibly early 19th century date. Here they installed the

hydraulic water-pressure engine here at river level. As described above, after deepening the engine shaft and driving a 26 fathom level under the pipeworkings then actively being mined, they used the shaft to pump from the sole of the mine.

Engine Chambers - We know that the main engine shaft chamber had the hydraulic water pressure engine installed here in *c.* 1838 by the North Staffordshire Lead and Copper Mining Company. However, while this shaft had almost certainly already been in existence for several decades, what is not fully clear is whether the chamber was also older than the late-1830s. It is likely that the Dale Mine Company's Newcomen-type engine's pump rods needed a balance bob from the outset and the obvious place for this is the chamber, but this chamber may have been significantly enlarged when the hydraulic water pressure engine was installed.

It can be postulated that the abandoned engine chamber that can be entered at river level was created in conjunction with the new shaft from surface above that was stared in 1836 by the North Staffordshire Lead and Copper Mining Company. However, while this possibility cannot be fully discounted, given the position of the chamber in relation to the surface remains, with no sign of shaft sinking above it, it seems far more likely that the chamber is a somewhat later feature. The most probable interpretation is that it was started in the early 1840s, as part of new infrastructure planned by Buckley, the agent of the North Staffordshire Lead and Copper Mining Company, shortly before they stopped work. Another possible interpretation is that the Dale Mining Company Ltd created the chamber in 1857, as their 1856 prospectus states that they intended to install a waterwheel to be used for pumping from depth. We know from a lack of documentation in the shareholder reports in the Mining Journal that the wheel was never put to work and the scheme must have been abandoned. In either event, the archaeological evidence in the pumpway shows it was to be connected to the main engine chamber by flat rods. An 1840s-50s interpretation is supported by the large shotholes in the abandoned engine chamber and in an unfinished flat-rod link along the pumpway to the engine shaft. This is also consistent with the documented significant extension of the pumpway in the early 1860s, in that the abandoned engine chamber may well have been backfilled with deads at this time at latest.

The Pumpway Extension - If the interpretation of the abandoned engine chamber just given is correct, then, given that the shotholes indicate the passage between the two chambers is earlier than the chamber, the date of the pumpway level beyond the main engine shaft chamber needs to be considered. Here there are significant uncertainties. While we know there was a significant extension in the early 1860s, made to reach the new engine shaft much further to the north, we do not know the starting point for this. It must have been beyond the abandoned engine chamber and may well have been significantly further along the pumpway. One possibility is that the original pumpway of the late 18th or early 19th century went well beyond the main engine shaft. However, another interesting and stronger possibility, is that the pumpway level was extended in search for more ore deposits by John Williams and Partners in 1847-52, and perhaps extended again by their successors in 1852-54. We know they were not working below river level between 1847 and 1854 and it may well be that the small pipeworkings ascending to surface were already worked out. Thus, extending the pumpway at this time seems a real possibility. They clearly did not find viable ore deposits here and how far the level was extended in an attempt to do this is unknown; they may have reached The Lumb and this would explain the lack of an identifiable change in drivage in terms of shothole size and passage character between here and the engine chambers. A related question is why does the Level turn to trend westwards and then turn again to run

north-westwards? One possibility is that they were seeking a continuation of Johnsons Load that was mined below river level; this said, the geological association between the Load and The Lumb above is not known. However, if this is the case then Johnsons Load, presumably named after William Johnson one of the partners in the 1852-57 venture, does not seem to have been in work below river level until after a steam pumping engine was put to work in 1855. Thus, unless earlier work here happened but is not identifiable in the surviving records, then it may be that the pumpway extension westwards may be equally late, dating to the second half of the 1850s.

Mining in the 1850s - A mine-section drawn in about 1860 shows that by this date the workings below river level done by the Dale Mine Company Ltd and previously by the mining partners that set this company up, were extensive and they had mined to below a tramway level at 43 fathoms beneath river level (Figure 6 above; Porter and Robey 2000, p. 126). In the mid-1850s flat rods and pump pipes were installed running down the pipeworkings from only a short distance below the pumpway horizon to the then sole of the mine; they were gradually extended as mining went deeper. These went well below the base of the main pumping shaft at its final depth as used in the 1830s-40s and thus this was not an effective point from which to pump from; while they could have deepened this shaft, it would have needed a significantly longer cross-cut level to reach the workings and doing this must have been decided against.

Mining in the 1860s-70s - Radical change came in 1861-63 when a new deep shaft was sunk well to the north-west, which allowed a more efficient way of bringing of ore to surface. The 1854-55 steam engine, which had been converted for winding and crushing engine in 1859, was transferred to the new shaft head. This shaft allowed a straight lift from near the base of the workings rather than bringing ore up the pipeworkings, which must have been labour intensive and time consuming. Pump rods were put in the new shaft, powered by flat rods at surface coming from the pre-existing 1859 pumping engine at the old main engine shaft. In addition, pumping also continued as before from this same engine, using the old engine shaft. As time had gone on, in the years immediately previous to the sinking of the new shaft, the flat rods must have become increasing inefficient as the number of pump rods and pump pipes needed to be increased. This was militated against with the installation of the more powerful engine in 1859 and then by the supplementary pump rods in the new shaft in the early 1860s. We know that the pumpway level was extended to the new shaft, with this primarily used to bring water to the river from the pipeworkings in this vicinity. The pumpway extension was eventually taken as an exploratory access and drainage level well beyond the new shaft to reach Cowclose Mine near Warslow Hall, as shown by a mine plan drawn at the time (Porter and Robey 2000, p. 10).

In the last phase of mining, under the New Dale Mining Company set up in 1868, it seems that use of the extraction infrastructure continued much as before, but it is recorded that viable ore deposits had already become hard to find at the sole of the mine, leading to reworking the pipe deposits higher up in an attempt to find good deposits missed earlier. These proved disappointing and the mine was closed in 1873.

Engines: Various engines used to facilitate dewatering the pipe deposit and bringing ore to surface were installed through time at Dale Mine; others were proposed but never installed. The various types of engine are described in turn below.

Horse-Drawn Winding Whims - There are gin circles for horse-drawn engines still visible today on site. The best preserved is that east of the main engine shaft, while a flat terrace with a curved cut in the slope next to Footway Shaft may well indicate the site of a second. Both of these horse-drawn engines were of the 'whim' type, where a large horizontal drum for winding ropes was placed to one side of the shaft, with the ropes coming from the drum to a headframe over the shaft. This had pulleys for two ropes (actually two ends of the same rope wound around the drum) that, after passing over these, went vertically down the shaft and were attached to kibbles (or barrels) for bringing ore (or water) out of the mine. At a particular moment in time, one of these ropes was attached to a kibble at the base of the shaft where it was ready for loading, while the kibble on the other rope was at the top of the shaft ready for unloading. As the horse walked around a circular horse walk below the drum, known as a gin circle, the first kibble was drawn up while the other went down the shaft. In order to reverse the process the horse had to be turned so that it walked in the opposite direction. The winding drum was normally placed above head height, both to allow room for the horses that drew the drum around and to give space at ground level for unloading the kibbles. The horse, or sometimes two or more horses, was attached to the drum via a harness fastened to a pole (or poles) that came down from its outer edge. The drum, which had central vertical axle timber that went down to a bearing block set in the ground, was held in place by a timber frame with vertical supports outside the horse walk.

The Footway Shaft gin, located to the south-east of the main mine complex, must be 18th century in date and predates the detailed documentation of Dale Mine from the 1790s onwards; budding waste nearby indicates it was used to bring ore to surface for processing.

The gin circle east of the main engine shaft, with an adjacent shaft on what is thought to be '*Sawpit Vein*', may well be of comparable date. If this shaft is early, as postulated here, then this would explain the gin circle's position immediately next to it, as this was normal with such engines. However the same gin circle may well also have been used later in conjunction with the main engine shaft sunk in the *c.* 1790-1810 period, with the gin placed at an atypical distance from the shaft because the gin circle already existed to the east and thus the expense of creating a new one on the restrictive sloping site was avoided; it probably continued in use intermittently until 1859. Horse-drawn winding whims, which are made of timber and thus have only a limited life and would have been replaced, like with like, at intervals, with this presumably normally taking place when new mining ventures started, especially if the old engine was in disrepair after years of neglect.

Later use of the eastern gin circle may well relate to one or more of the direct or indirect documentary references to the use of this type of engine at Dale Mine. These potential later uses of this gin circle are:

- One used in *c.* 1790-1810 by the Dale Mine Company (*c.* 1790s - 1810s) for bringing ore to surface, presumably via the main engine shaft.
- The Warslow Mineral Company (1823 - *c.* 1830) had a horse gin for drawing water, presumably using barrels, at the main engine shaft.

- The North Staffordshire Lead and Copper Mining Company (1836-1843) started sinking a new engine shaft in 1836 and may well have used a horse gin to bring out the rock being removed; this gin may have been sited next to the new shaft in the area modified in the 1850s when engine houses were added, or alternatively they had continued to use the pre-existing gin circle to the south-east.
- From 1838 the North Staffordshire Lead and Copper Mining Company used a horse gin to bring ore to surface via the main engine shaft extant from the *c.* 1790s - 1810s period.
- Between 1855 and 1859, first used by the 1852–1857 partnership and then the Dale Mining Company Ltd that they established in 1857, they were drawing ore up the main engine shaft. Given that the extant gin circle was never disturbed and there was no room for a second gin circle near the engine shaft because of the positions of adjacent buildings and the dressing floor, they may well have continued to use the old gin site to the east.

It seems likely that the surviving gin circle was used at the mine from the 18th century through to 1859 when a steam winder was installed, after which there would have been no need for a horse-drawn winding whim.

Steam-Powered Engines - Four steam engine houses were built at Dale Mine between the late 18th century and the 1860s, two used exclusively for pumping, another similarly used but later converted for winding and crushing, and the fourth for the same engine as the last but at a different site. These are:

- A small Newcomen-type pumping engine erected near the collar of the main engine shaft; it is unclear of this was sited to the north or east of the latter, but the former position seems most likely. It may well have been installed in the 1790s and was probably disused by 1810 at latest. It had an 18 inch (0.46m) diameter vertical cylinder and the pumping beam had arch heads with chains, while the boiler, of haystack type, was circular and 5.5ft (1.7m) in diameter. After a period of disuse, the engine house was demolished in 1823.
- A Cornish-type winding engine, that was bought second-hand from Hazelbarrow Colliery and converted to be used for pumping at Dale Mine. It was erected here in 1854-55 near the collar of the main engine shaft, sited to the north side; it was connected to the pump rods via a short series of flat rods. In 1859, after a larger pumping engine was erected on site, the 1854-55 engine was converted for use winding and crushing. The engine was small, with a vertical 19 inch (0.48m) diameter cylinder; no other details are known. It was removed in 1862 to the shaft to the north-west and the old engine house was blown up.
- A Cornish-type pumping engine, bought second-hand for £2,600 from the nearby New York Mine where it had been installed in 1849. It was erected at Dale Mine in 1859, with the engine house perhaps started in the year before, sited near to the shaft collar of the main engine shaft, to its east side. The engine had a cylinder diameter of 40 inches (1.0m), with a 9ft (2.75m) stroke at the cylinder and a 7ft (2.15m) stroke in the shaft, which could work to a maximum of a little over ten strokes per minute. The engine house must have been removed relatively soon after the mine ceased work in 1873 as it had gone by 1878.
- The 19-inch cylinder Cornish-type engine was moved to a new site in 1862, with the engine house perhaps started the year before, placed next to the new engine shaft well to the north-west of the area surveyed in 2018. It again was used for winding and

crushing, with ore-processing jigs probably also connected, and worked until 1873. This was still standing in 1878 but had gone by 1897.

The *c.* 1838 Hydraulic Water-Pressure Engine - This type of engine, designed to be installed underground, relied on the weight of water in a vertical pipe leading down to it, the pressure created at the engine providing the power to operate a pump or pumps placed further down the shaft. That at Dale was erected in a chamber next to the pumpway, and was in the process of being installed by an engineer named Joseph North when Queen Victoria was crowned in June 1838. All we know of its design from historical documentation is that it had 12-inch (0.30m) diameter piston, with a pumping beam that had a six foot (1.80m) stroke with this moving pump rods attached to the pump at the base of the engine shaft below the chamber; this brought the water up pump pipes to the pumpway so that it could be let out here taken to the river. The implication of the six foot stroke is that the pumping beam was relatively long.

The engine was removed after it ceased being used in 1843 when The North Staffordshire Lead and Copper Mining Company ceased work at Dale Mine. However, the chamber in which it stood is still accessible for study. During the survey of 2015-16 a detailed record was made of a multitude of notches in the wall for timbers, and other features, in an attempt to learn something of the design of the engine and to investigate whether the chamber had also been used for other machinery.

The chamber is 11.5m long and 3.5-4.5m wide. The main engine shaft from surface is at the end furthest from the pumpway; where it enters the chamber roof it is *c.* 1.8m across. At the chamber floor it is 3.5m long and 1.6m wide, with the extra length bringing one half of the shaft further into the chamber. The central part of the chamber is 6.0-6.5m high but at the far end from the shaft there is a roof cavity and the total height here is 10.5m. At one side of the chamber beneath the roof cavity there is a large pack of deads that presumably had been placed here after the hydraulic water-pressure engine was removed.

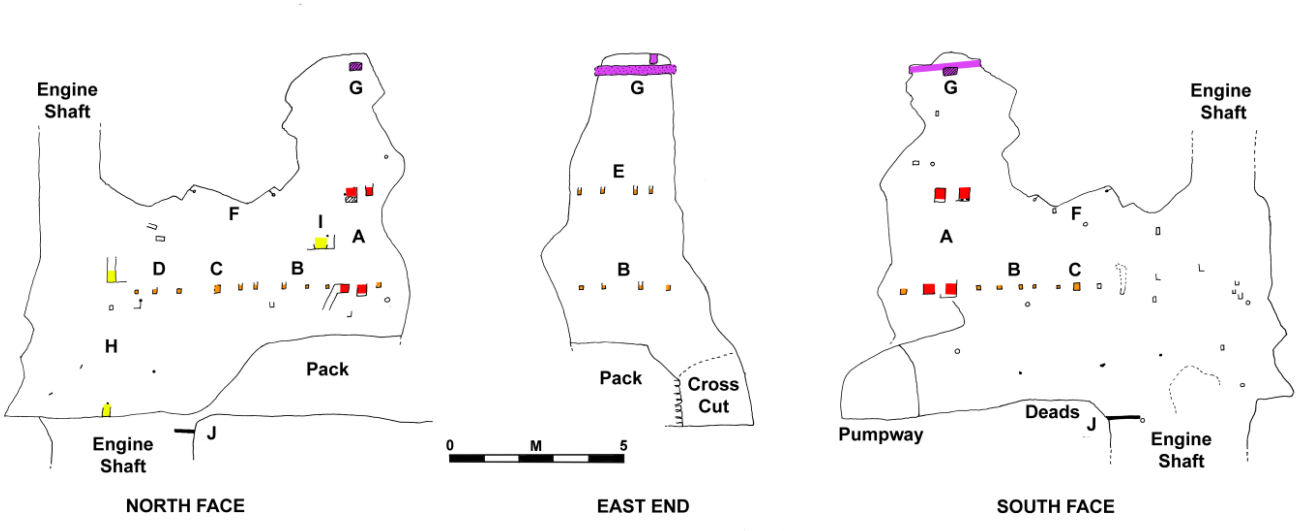

Figure 13: The underground hydraulic water pressure engine chamber and shaft, showing timbers, notches and slots for timbers, and metal fittings (for A-I see text).

Notches for timbers holding machinery are located at the eastern end of the chamber under the roof cavity here. There were two sets of large rectangular sectioned timbers, each with notches in both north and south walls, with their bases at *c.* 3.5m and 6.3m above the chamber floor (Fig 13: A). Each set comprised two timbers placed close apart, with a gap of *c.* 20cm between them, except for the upper pair on the south face which is *c.* 40cm (the lower pair to the south side are only 8cm apart, but here the western timber slot was cut wider than was needed and the real gap again may have been *c.* 20cm). These four timbers presumably supported substantive near-vertically-set machinery.

Plate 42: Two of the notches for sturdy paired timbers in the engine shaft chamber, on its north face, which are interpreted as supporting the hydraulic water pressure engine; that to the left has a diagonal slot cut to raise this end of the beam into place. The slot behind at the centre of the photograph had its timber placed from above (Photograph: Mat and Niki Adlam Stiles).

There is also clear evidence for two timber floors having been placed across the chamber. The lower of these (Fig 13: B) spanned the full width of the chamber, with joist slots in north, south and east walls, and was set *c.* 3.9m above the chamber floor at roughly the same height as the lower pair of machinery timbers. The western end of the floor may be marked by a somewhat more substantial timber (Fig 13: C). Evidence for a continuation further west is less certainly interpreted as there are clear joist slots on only the north side, set at a slightly lower level that those further east (Fig 13: D); perhaps there was a walkway only to the north, not matched on the other side. The upper timber floor again spanned the full width of the chamber, but there are only joist slots at the east end wall (Fig 13: E). It was placed *c.* 6.6m above the chamber floor at roughly the same height as the upper pair of machinery timbers. The other end of the floor joists may well have been set in one or both of these beams.

Other significant features include a pair of iron bars with looped ends (Fig 13: F), placed in the chamber roof on the centre line of the chamber, which were presumably for supporting machinery or hauling this into place. There is also a surviving horizontal roof beam in the eastern roof cavity (Fig 13: G), with notches for a now-gone cross-beam above, presumably used with block and tackle for lifting machinery into place. Three other slots for large timbers, two at the shaft side (Fig 13: H) and one further east (Fig 13: I) are harder to interpret, especially as they are not clearly matched on the other side of the chamber; perhaps

the two at the shaft side supported a brattice that separated the winding part of the shaft from the chamber. Two iron rails just below floor level over the end of the shaft have been reused to support a working platform rather than there having ever been a tramway here (Fig 13: J). A variety of other small timber notches and iron pins are again not easy to interpret.

Plate 43: two of the slots at the eastern end of the engine shaft chamber for the timbers supporting the lower raised floor (Photograph: Rod Dalton).

Plate 44: looking up at the surviving timber in the roof cavity at the eastern end of the hydraulic water pressure engine chamber (Photograph: Mat and Niki Adlam Stiles).

While the survey gives clear indications of something substantive that was set vertically near the east end of the chamber, with two raised floors associated with this, the basic question is what was the character of the machinery installed here. The obvious interpretation is that it was the *c.* 1838 hydraulic water pressure engine; the header pipe from surface would have been placed against the eastern side of the shaft to keep the rest clear for winding ore and would then have run horizontally close to the chamber roof to reach the near-vertically placed engine cylinder near its top. The raised floors would have been for operating the engine and its maintenance. The roof cavity above would have been created to give clearance for lifting equipment used when the engine cylinder was put in place. The pump rods and pump pipes would have been in the offset eastern part of the shaft going downwards; this would have been necessary as the main part of the shaft needed to be kept clear for winding ore to surface. The engine itself could not have been placed in the eastern part of the shaft as it is documented that it had a substantive pumping beam to operate the pump rods; this would have had one end under the engine cylinder and the other above the pump rods.

Plate 45: The flooded downward continuation of the main engine shaft is divided into two compartments; the near half, where the pump rods and pump pipes are likely to have been placed, has reused rails that supported an access platform here. The far half was used for winding ore from depth (Photograph: Mat and Niki Adlam Stiles).

The engine timbers that supported the near-vertical 'cylinder' are a long way east of the engine shaft and given that we know the engine had a pumping beam with a six foot stroke, this must have been a substantive timber or cast iron beam. There are no obvious timber support notches for this and thus it must have been relatively close to the ground, set below the engine, with a timber frame that did rely on the chamber walls for support. If the pumping beam went straight from the engine base to the pump rods, then it would have been about 15ft (5m) long, with its pivot point about half way along. This pumping beam is likely to have effectively acted as a balance bob for the pump rods.

If the machinery timbers and raised floors were for different equipment than proposed here it is hard to envisage what this would have been. The chamber could predate the 1830s; a balance bob would have been necessary for the Newcomen type engine's pump rods and it may be that the chamber held this. This would have been set on the floor rather than being raised off the ground and in this scenario the eastern machinery timbers and raised floors remain unexplained, strengthening the interpretation of these being associated with the hydraulic water pressure engine. A chamber for a balance bob would not have needed to have been nearly as high as what is seen today, so presumably this was heightened when the water pressure engine was installed.

Several hydraulic water pressure engines were installed at mines in the Peak District in the first half of the 19th century, as listed here in chronological order:

- 1803-05 - Crashpurse Shaft, Alport (SK 215638): This engine was designed by Richard Trevithick and was placed 150ft (45.5m) underground and used to pump water up 48ft (14.5m) to a branch of Hillcarr Sough. It was set to work in 1805, was moved to Old Engine Shaft in 1813 (see below), but later returned to its original site; it worked for a total of 47 years. It had a cylinder of 25 inches (0.64m) diameter and used 416 gallons per stroke, of which there were three per minute, and it pumped 280 gallons per stroke (Rieuwerts 1993, pp. 19, 24, 53; Rieuwerts 2008, p. 119).
- *c.* 1807-10 - Bacon Close, Alport (SK 219638): This engine was designed by Richard Page, was erected on Bacon Close Vein at what became known as Pages Shaft, and pumped water up to an horizon drained by a branch of Hillcarr Sough (Rieuwerts 1993, pp. 20, 24, 53; Rieuwerts 2008, p. 119).
- 1813 - Old Engine Shaft, Alport (SK 218636): Trevithick's 1803-05 Crashpurse Shaft engine was moved here in 1813 and pumped water to a branch of Hillcarr Sough, but was later returned to its original site (Rieuwerts 1993, p. 19; Rieuwerts 2008, p. 119).
- 1819 - Broadmeadow Shaft, Alport (SK 224643): This engine was sited close to the Shining Sough branch of Hillcarr Sough and was made at Coalbrookdale Ironworks. It worked until *c.* 1827 and was later moved to Wills Founder near Winster (see below). At the original site it was fed by water from the River Lathkill via a long underground shale gate. It had a cylinder of 18 inches (0.46m) diameter and used 838 gallons per minute to raise about 550 gallons per minute (Rieuwerts 1993, pp. 19, 24-5, 53; Rieuwerts 2008, p. 119).
- 1836 - Broadmeadow Shaft, Alport (SK 224636): This second engine at Broadmeadow Shaft was made by William Fairbairn and Co. of Manchester and replaced that made at Coalbrookdale. It was also fed by water from the River Lathkill via the long underground shale gate. It had a cylinder of 36 inches (0.90m) diameter and used 303 gallons per stroke to raise 214 gallons per stroke (Rieuwerts 1993, pp. 19, 25, 53; Rieuwerts 2008, p. 119).
- 1838 - Dale Mine, Warslow: see above.

- *c.* 1840 - Wills Founder, Winster (SK 235606): This engine, made in 1819, was moved to the Portaway Title in *c.* 1837 from Broadmeadow Shaft at Alport for a deep trial and was installed at 360ft (110m) underground by Samuel Trethewy in *c.* 1840. It raised water to a branch of Yatestoup Sough. Water was dropped 140ft (42.5m) down a pipe to the engine. This engine was removed in the 1978 by members of the Peak District Mines Historical Society and placed in the Peak District Lead Mining Museum at Matlock Bath (Willies 1977; Rieuwerts 2008, p. 119).
- 1842 - Guy Shaft, Alport (SK 220638): This engine was made at the Butterley Ironworks and was installed by John Taylor for the Alport Mining Company, which had been formed in 1839 (Rieuwerts 2008, p. 119). It was placed 210ft (64m) below surface and its cylinder had a 50 inch (1.27m) diameter, it lifted 5,000 gallons per minute from 140ft (42.5m) below Hillcarr Sough and used 7,150 gallons of water dropped down a pipe for 132ft (40.0m). The water from the River Lathkill was brought via a long underground shale gate that was extended from Broadmeadow Shaft for this purpose. The Alport Mining Company mines closed in 1851 (Rieuwerts 1993, pp. 20, 54; Rieuwerts 2008, p. 119-20).
- 1842 or later - Guy Shaft, Alport (SK 220638): This Alport Mining Company shaft also had a second hydraulic water pressure engine, with a cylinder of 18 inches, used to assist the pumping. It was made at the Milton Ironworks at Elsecar near Barnsley in Yorkshire (Rieuwerts 2008, p. 120).
- 1845 - Pienetnest Shaft, Alport (SK 216638): This engine was installed on a branch of Hillcarr Sough and was also made for the Alport Mining Company at the Milton Ironworks. It had two 24 inch (0.61m) diameter cylinders and used 384 gallons of water per stroke to raise 265 gallons. It worked until 1848 (Rieuwerts 1993, pp. 20, 25, 54; Rieuwerts 2008, p. 120).
- 1848 - Kirkmeadow Shaft, Alport (SK 233644): This engine was placed on Thornhill Sough, a branch of Hillcarr Sough, for the Alport Mining Company. It had a 24 inch (0.61m) diameter cylinder, with 28 inch (0.71m) diameter pumps, and lifted water 48ft (14.5m). The Alport Mining Company mines closed in 1851 (Rieuwerts 1993, pp. 11, 14, 25, 54; Rieuwerts 2008, pp. 120-21).

The Dale Mine hydraulic water-pressure engine stands out as being installed at only one of two places where such engines were used in the region away from the Alport mining field centred on the parish of Harthill; the other, at Wills Founder, was a reuse of an engine from the Alport area. Unlike much of the Derbyshire lead orefield, the wet Alport mines had shaft tops on relatively low ground where surface water supply was relatively plentiful; eight separate engines were installed here. The Dale Mine site is similar in that it lies close to the interface between the Carboniferous Limestone and overlying impervious rocks on higher land, thus water supply again was not a problem. The chamber for this engine is the only one in the Peak District that is still easily accessible.

The first known hydraulic water pressure engine to be used in Britain was in the Northern Pennines by 1769 (Rieuwerts 1993, p. 48), while the first flourish of engine installation at Alport came in 1803-19; one of these was replaced in 1836. A second flourish came in 1842-48 under the aegis of the Alport Mining Company, influenced by the well-known mining entrepreneur John Taylor who at the time ran these mines. The Dale Mine installation came in *c.* 1838, a short time before the second flourish, and was a venture independent of what was happening at Alport, although no doubt its builders were aware of the engines installed here between 1803 and 1836.

Uninstalled Engines and the Abandoned Engine Chamber - Although installation of a waterwheel was proposed in the 1856 prospectus for the Dale Mining Company Ltd, it seems likely this was never put in place. It was described as to be 35ft (10.5m) in diameter, 6ft (1.8m) in width and to be breast-shot. In preparation for its installation they may have started making a chamber in which it was to sit, located adjacent to the pumpway at a short distance north from the pumping shaft chamber previously used for the hydraulic water pressure engine of *c.* 1838. However, it seems much more likely that this chamber had been created in the early 1840s under the aegis of the then agent, George Buckley, just before the North Staffordshire Lead and Copper Mining Company stopped mining; a shaft from surface to the chamber was never started and we do not know what type of engine was to be installed.

The unfinished chamber measures just over 8m long by *c.* 3.5-4.0m wide and is about 6.75m high from the floor of the pumpway level. The character of the widening of the pumpway between the two chambers indicates it was the intention to connect the engine that was to be installed in the unfinished chamber, using flat rods, with the pump rods in the pre-existing pumping shaft, hence a shaft from surface was not intended to be sunk below river level. Where the water to operate the engine, assuming it was a hydraulic water pressure engine or waterwheel, was to be brought from is not clear; there is no obvious source underground so presumably it was to come from surface via a shaft that was never sunk. If dating to the early 1840s, the *c.* 1838 leat used for the hydraulic water pressure engine was presumably still serviceable. Alternatively they may have intended to install a steam engine here.

That the unfinished chamber was not for the 1857 waterwheel of 35ft (10.5m) diameter is further suggested by its dimensions; it is too small. Given that the wheel was to be breast shot, unless the intention was to increase the height by the time it was finished, the lower part of the wheel pit would have had to be sunk below the pumpway level, which would have made disposal of this water difficult if not impossible. The length of the chamber is also somewhat short.

Ore Dressing: The earliest identified dressing floor on site lay immediately east of Footway Shaft where there are two small rectangular terraces with dressing waste dumped nearby; nothing is known of the equipment used but presumably they hand-crushed and sorted the ore and then used washing tubs and hand-operated buddles.

Later the dressing took place immediately west of the main engine shaft sunk in the late 18th century, or possibly the early 19th century, presumably with a dressing floor created at around the time the shaft was completed and put into use; dressing continued here until the early 1860s. Today the floor comprises a 10m (N/S) by 22m (E/W) flat area immediately west of the shaft, located between here and the main approach road to the mine; before the mid-1850s this dressing floor was presumably somewhat wider on the south side until the hillock top was robbed for zinc ore by Attwood between 1854 and 1856.

In 1859 the old pumping engine was converted to be used for winding ore up the shaft and for crushing ore; presumably there were rolls crushers installed on or adjacent to the long-used dressing floor that were attached to the engine. Below this floor, which from 1855-56 became the upper dressing floor once another had been added below, on a lower terrace the miners now had a bank of six stone-built tanks erected. These have openings on the downslope side, with four small examples to the south-east half and two larger ones to the north-west that may have been added later. These tanks are interpreted here as ‘ore bins’ belonging to the second half of the 1850s, built soon after the original dressing floor had been

reduced in size. They are suggested to have been made to contain part-dressed ores, where they were washed to make them ready for further ore processing on the new lower dressing floor that lay adjacent. This is a flat area that measures 12m by 12m, and here it is thought they were using hotches, and buddles, with the resulting concentrated ore removed along the lower access roadway built for this purpose.

Plate 46: The south-eastern part of the 'ore bins', with robbed retaining wall and four openings that led from the tanks behind; the western half of the 'ore bins', where there were two openings, is shrouded by trees but with one of these just visible.

The 'ore bins' were presumably placed where they were out of necessity after Attwood robbed the hillock, reducing the size of the main dressing floor above, which now may well not have had space for final ore processing and storage. They also represent a rationalisation of the dressing process to make this more efficient, with part-processed ore sent down chutes to the storage tanks rather than these being placed on the dressing floor above, as this would have entailed more work to fill them.

Today there are no visible features on the upper and lower floors and all the dressing equipment was almost certainly above ground or wooden, although archaeological excavation would presumably reveal the bases of buried structures, etc. (for example see Barnatt 2011). The types of dressing equipment used in the early years of the use of the floors is undocumented but again would have presumably comprised simple hand-operated equipment for ore concentration, including washing tubs and buddles; as time went by hotches may well have been used. In 1878, about 15 years after the floors were abandoned, the first edition of the detailed 25 inch to a mile Ordnance Survey map shows a very small rectangular structure, presumably stone-built, next to the entrance to the upper floor to the west; its purpose is obscure.

From 1863 dressing took place near the new engine shaft well to the north-west of the area surveyed in 2018. Here it is documented the floor was flagged and they had a double rolls crusher for the ore, powered by the steam engine at the shaft top, and also '*hutches or jigging tubs*', '*buddles*' and '*catch pits*' that allowed them to maximize the recovery of ore down to the finest material that came from the crusher. The jigging tubs may well also have been powered by the engine. Taking this documented 1860s plant together, they were typical of the semi-mechanised dressing equipment used at larger mines of the period (Palmer and Neverson 1989; Barnatt 2011; 2012).

Plate 47: One of the downslope openings into the four tanks at the south-eastern end of the 'ore bins'.

Overview: Dale Mine has a fascinating history that revolves around solving the problems of working a deep mineralised pipe deposit that went diagonally downwards to below river level. This ore deposit at Dale Mine was probably found in the early to mid-18th century and started to be mined below river level late in the same century. While the pipe deposits were only small above river level they got larger at depth, but here it became ever-increasingly difficult to win the ore. A series of pumping and winding engines were installed from the late 18th century or early 19th century to the 1860s to attempt to solve the problems of extraction. Various people and mining companies tried to make this mine economically viable but each

gave up after several years and there were two or possibly three short periods where the mine stood idle.

Table 1: Summary of phases and character of working at Dale Mine.

Date	*Miner Operators*	*Mining above river*	*Mining below river*	*Notes*
18th century	Unknown	X		Working here by 1766 at latest Horse-drawn winding whim at Footway Shaft Probable horse-drawn winding whim on '*Sawpit Vein*'
c. 1790s–1810s	Dale Mine Company		X	Newcomen pumping engine Horse-drawn winding whim
1810s-1823	-			Not in work
1823- *c*. 1830	Warslow Mineral Company		X	Horse-drawn winding whim
c. 1830-1836	-			Possibly not in work
1836-1843	The North Staffordshire Lead and Copper Mining Company		X	Hydraulic water pressure engine Horse-drawn winding whim New engine planned in the early 1840s (never installed)
1843-1847	-			Not in work
1847-1852	John Williams and Partners	X		Small scale work
1852-1857	James Pemberton, Thomas Lewis, William Johnson, Charles Lewis and Partners		X	Cornish-type pumping engine from 1854-55 Waterwheel for pumping proposed in 1856 (never installed) Horse-drawn winding whim
1854-1856	Melville Attwood	X		Reworking the main hillock
1857-1868	Dale Mining Company Ltd		X	Cornish-type pumping engine Horse-drawn winding whim to 1859 Cornish winding engine from 1859 (in use at the northern shaft from 1863)
1868-1873	New Dale Mining Company		X	Cornish-type pumping engine (Cornish-type winding engine at the northern shaft)

Over time the mine had more steam-powered and water powered engines installed than at any other metal mine in the region, with the exception of the Yatestoup lead mine near Winster in Derbyshire in the 18th century (Rieuwerts 2010, pp. 48-57; Barnatt 2018, pp. 78-85).

The mine was occasionally in profit on a month by month basis, with this documented from 1859 to 1865 as fluctuating intermittently between profit and loss, and in addition perhaps money was made in the 1790s-1810s and 1836-43 periods for which we have no detailed information. However, Dale Mine almost certainly never made significant amounts of money when the cost of installing the pumping and extraction infrastructure is accounted for. Often the various mining ventures were running at a loss, with shareholders sinking more and more money into the mine without seeing a return. In overall terms it was a financial failure, while at the same time keeping local miners in employment for over a century.

Appendix 1: The Surface Survey Catalogue

The locations of all the features recorded in 2018 and listed below are identified on Figure 14.

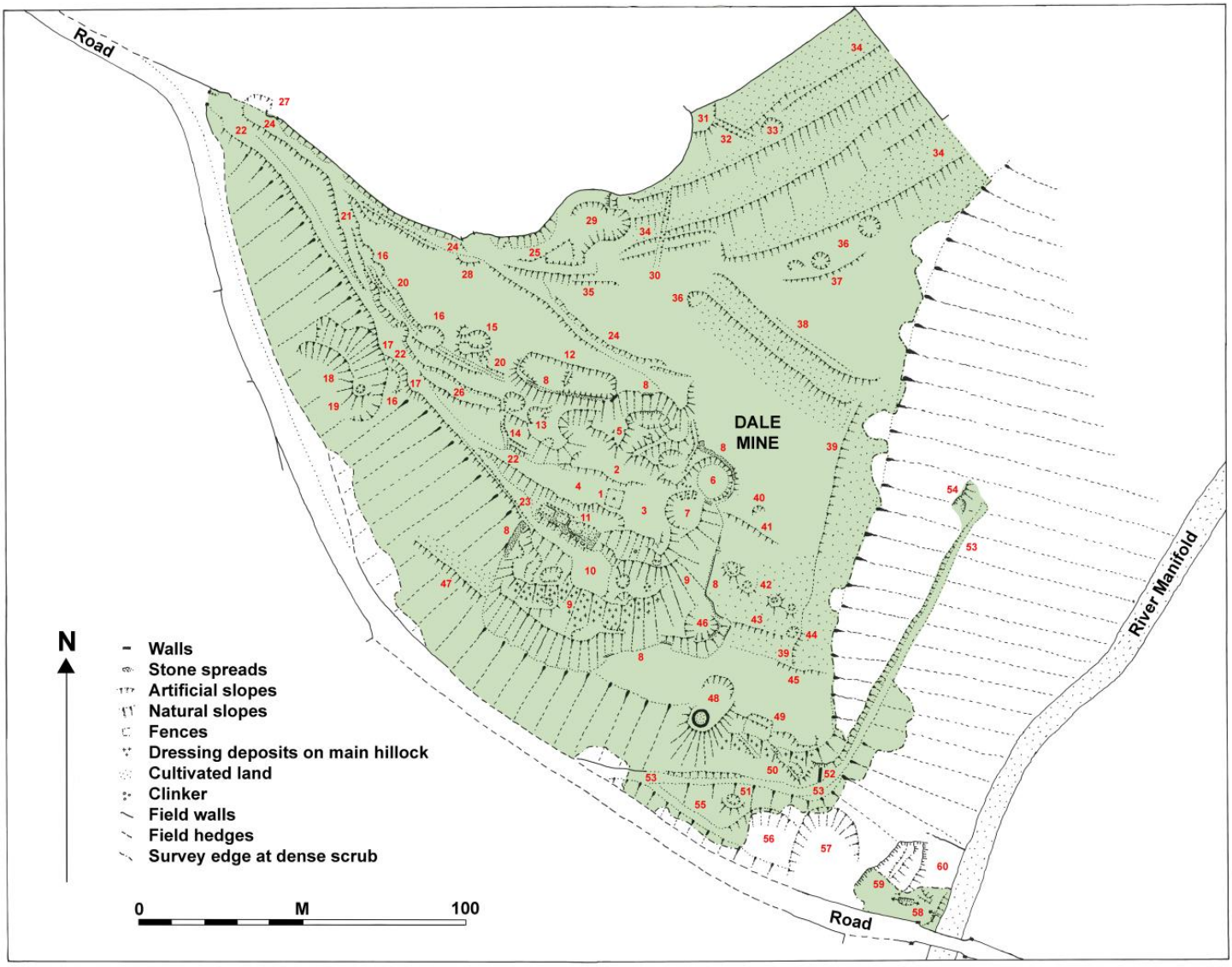

Figure 14: The archaeological surface survey catalogue numbers, with the area surveyed shown in pale green (for 1-60 see text).

1: Engine Shaft (Capped), Dressing Floor and Site of Small Structure

The main Dale Mine engine shaft, used for pumping and hauling up ore, is visible underground at one end of a large chamber that once held a hydraulic water-pressure engine. This shaft comes to surface near the centre of the flat ground at the centre of the main mine complex. Before 2008 it was wrongly assumed (by this author at least) that this engine shaft lay a short distance to the east at Feature 7. While there is nothing at surface today to indicate that the flat ground at Feature 1 is the site of the engine shaft, in 2008 a small hole was dug here by a local mining enthusiast, without permission, which proved this was the case. The hole showed that there was something like 1.5m of fill above a rotted timber capping with void underneath. The metal pipe that protrudes from the ground today within the fenced area is at the site of the hole dug. What is unclear (to this author) is whether the 2008 hole was at the centre of the shaft or towards one of its sides.

The flat area around the shaft top was a working platform and we know from documentation that three engine houses stood here at different dates as well as a smithy and carpenters shop. The sites of these buildings are indicated by Features 2 and 3, while to the west at Feature 4 there was a dressing floor. Immediately to the south of the site of the engine shaft there is a robber pit edge and the working platform here may originally have extended over this area for some distance to the south before the upper part of the hillock was partially removed for previously discarded zinc ore in 1854-56 (see Feature 9); this robbed area may have also been used for dressing prior to this date.

The date of the main shaft at Feature 1 is not fully clear, but it seems very likely that this was the shaft used for the pump rods and pump pipes of the Newcomen-type pumping engine erected in the late 18th century or early 19th century. This postulation is made especially likely as the Footway Shaft (Feature 48), does not extend down to the parts of the workings that would flood and there are no signs of any buildings at surface here; there are no other deep shafts on site, except a possible now-filled example at the eastern side of Feature 5 that is interpreted here as sunk in 1836 but aborted before it was finished. The Feature 1 shaft may well have been sunk especially for the Newcomen-type engine and it was certainly in use later to take water down the hydraulic water-pressure engine from *c.* 1838 onwards. It continued in use into the 1860s-70s.

2: Platform (Site of Engine House or Engine Houses)
A flat topped area between the main part of the working platform around Feature 1 and the quarry at Feature 5 has a 0.5m high break of slope to its south side. At the western end of the platform the ground above is truncated with a break of slope that is 0.3m high. Together these lynchets help define a sub-rectangular area that may mark one end and sides of an engine house, boiler house and coal yard, with the slightly protruding part of the southern edge presumably marking the end of the engine house that faced the engine shaft.

An 1860s mine plan shows details of the *c.* 1857-59 period (Porter and Robey 1973, p. 172). Here the 1854-55 engine house stood on Platform 2, with the engine at first used for pumping from the engine shaft at Feature 1. After 1859 it was converted to be used for winding and crushing; the attached boiler house lay east of the engine house. The crusher would have been placed in a convenient place in relation to the dressing floor that lay to the west of the shaft (Feature 4) and a coal yard was also located in this area. At an earlier date the Newcomen-type engine house, later converted to an ore-storage house, could have stood either on Platform 2 or Platform 3, with the former being more likely.

The distance between Platform 2 and the engine shaft is not normal for a pumping engine, with the engine house usually erected immediately next to the shaft so that it could be connected directly to the pump rods going down the shaft. This distance is explained by two 1850-60s drawn mine sections of Dale Mine, both showing a short section of flat rods running between the 1854-55 engine house and the pump rods in the shaft (Porter and Robey 2000, pp. 122, 126).

3: Platform (Site of Engine House or Engine Houses and Other Buildings)
A flat topped area to the east of the site of the engine shaft at Feature 1 has a break of slope that is up to 0.50m high at its south-eastern corner; this platform may well mark the site of 19th century buildings that are documented as standing near the shaft. We know that two engine houses were in work in 1859-1861, one used for pumping, the other used for winding and crushing. An 1860s mine plan shows details of the *c.* 1857-59 period (Porter and Robey

1973, p. 172). At this date the 1854-55 engine house stood on Platform 2, with a smithy and carpenters shop on Platform 3, respectively south-east and east of the shaft. The smithy was at the approximate site of an 1859 steam engine house, hence it must have been demolished to make way for the new pumping engine; a new smithy would have been needed but its site is unknown. At an earlier date the Newcomen-type engine house, later converted to an ore-storage house, could have stood either on Platform 2 or Platform 3, with the former being more likely.

4: Upper Dressing Floor and Site of Structure

The now-featureless flat area west of the shaft is documented as being a dressing floor. Much of the dressing plant at 19th century mines was normally timber-made and doesn't usually survive.

The upper dressing floor may well have existed from the time the shaft was sunk and the Newcomen-type engine was erected here in the late 18th century or early 19th century and it was in use until the early 1860s. As there is also a lower dressing floor added in the mid-1850s at Feature 10, Feature 4 is catalogued as the upper dressing floor.

To the north-west, against the upslope side of Access Roadway 22, where it widens as it enters the dressing floor, the Ordnance Survey 25 inch to a mile map of the area (Sheet IX.2), surveyed in 1878 and published in the next year, shows a very small, long and thin, structure of unknown interpretation; it had been removed by the time of the second edition revised in 1897 and no trace of this was seen in 2018.

5: Stone Quarry, Waste Heaps and Probable Site of Aborted Engine Shaft

A relatively deep quarry cut into the upper daleside slope, which is *c.* 4-5m deep on the upslope side. The original quarry face for the most part is now not visible, buried by material that has subsequently spilled down the slope, except in one area to the north-east where a rock-cut edge can be seen. Within the overall quarry area there is a series of amorphous hollows and low mounds, with two main quarry pits located at the north side, to the west and east ends, with the adjacent mounds explained as comprising piles of dumped waste material and perhaps areas of rock that was never removed.

It is thought this quarry was dug to provide stone for the some or all of the three engine house and other building that are known to have once stood nearby (see Features 1-4). While this is very probably the case for the two engine houses built in the 1850s, the source of stone for the earlier Newcomen-type engine house is less clear.

It is thought that a shaft was sunk somewhere in this area in 1836 but that this was abandoned before it was finished; there are now no clear indications of exactly where it was. One strong possibility is that it was at the main western hollow of Feature 5. An undated 19th century map of Dale Mine, drawn after the new 1860s shaft was sunk well to the north-west, shows a shaft somewhere in the general vicinity of the western part of Feature 5 and Feature 14, but it is difficult to know how accurate this map is (Porter and Robey 2000, p. 11); it seems unlikely that there was an open shaft here at this date. The map maker, if showing a documented old shaft, may have misinterpreted earthworks on site.

6: Gin Circle (Site of Horse-Drawn Winding Whim)

This is a well preserved example of a gin circle for a horse-drawn winding whim. The site of the engine is a flat-topped circular terrace, which originally would have had a horse walk at

its outer edge and a bearing block for the engines main vertical timber at the centre; neither of these can be clearly seen today. The gin platform is terraced into the slope, with a cutting to the upslope side that is just less than 2.0m deep; the downslope side is made up ground, presumably using material from the cut. The eastern half of the gin platform is edged by the belland yard wall (Feature 8).

While this horse-drawn winding whim may well have operated ropes going down the main engine shaft (Feature 1), having a whim at this kind of distance from a shaft is unusual and there is a much nearer shaft at Feature 7. The latter, which is interpreted as probably of 18th century date, seems likely to be the shaft initially used in conjunction with the horse-drawn engine. However, a whim here may well have reused the gin circle from the *c.* 1790s-1810s period onwards to then wind from the main engine shaft because there was a pre-existing platform; a steam-powered winding engine was installed in 1859 and the horse-drawn winding whim would then have become redundant.

7: Probable Run-In Shaft and Boiler Clinker

Adjacent to the Gin Circle 6, on the downslope side to the south-west, there is a an amorphous oval hollow that today is about 1.5m deep; this may well be at a collapsed shaft top rather than a fortuitous robbing hollow at the eastern end of the main mine hillock (Feature 9). The 2018 survey shows the feature effectively has its own discrete hillock rather than being integral with the main mine hillock. Thus, this hollow may well be at the site of a shaft sunk in the 18th century before the main engine shaft to depth was created (Feature 1).

There is boiler clinker scattered about the surface of the hollow that probably dates to the mid-1850s onwards, derived from the steam engine boilers (see Feature 9).

8: Belland Yard Wall

A ruined drystone wall, in long stretches collapsed and unrecognizable; it is visible against the western side of the mine's main hillock (feature 9), while in the downslope half to the south-west the wall's stone merges with that from the main hillock surrounding it. To the south-east it also encompasses Feature 46. To the east the belland yard wall runs below the hillock of Feature 7 and defines the edge of the eastern half of Gin Circle 6. Upslope to the north parts of the ruined belland yard wall are visible both at the eastern and northern edge of the Quarry at Feature 5 and at the southern edge of the mine's Reservoir Ponds at Feature 12. There is no trace of the wall to the north-west where the various access routes come to the main mine complex and here it seems sections between gateways have been purposefully removed; on the basis of the archaeological features alone its former course is unclear.

The Ordnance Survey 25 inch to a mile map of the area (Sheet IX.2), surveyed in 1878 and published in the next year, shows the belland yard wall as surrounding the whole of the main mine complex and confirms the walls at the top of the quarry at Feature 5 and at the reservoir edge at Feature 12 were part of it. The 1878 map also shows that at the western end of the reservoirs it then turned sharply to the south, in part defined by the robber trench at Feature 14, then bent south-east to come close to the south-western corner of the 'ore bins' at Feature 11.

The date that this wall was built is not clear and this may be as early as the first use of the engine shaft at Feature 1, which is thought to be in the late 18th century or early 19th century, but it seems far more likely that the wall was added during mining from the mid-1850s onwards, or after the Dale Mine was abandoned in 1873.

9: Main Mine Hillock, Dressing Waste and Boiler Clinker

This massive hillock has a downslope side that is largely bare of vegetation. Most of the material visible is limestone that must derive from shaft sinking or working through barren ground underground. However, in addition, on the slopes immediately south of the terrace at Feature 10 and areas to either side, there is smaller material exposed that is likely to derive from ore processing. The hillock top comprises flat ground around the top of the main engine shaft (Feature 1), while its downslope sides are often steeply sloping. However, at a horizon about 5.0m below the top, there is the flat terrace at Feature 10; the hillock side continues down beyond, with a height of about 8.0m below the terrace, making the total hillock height about 13m. The upper part of the slope below the terrace is relatively gentle and looks heavily robbed, while below it is significantly steeper. The hillock base is defined by Belland Yard Wall 8, both at still-extant parts and where it has collapsed and become buried.

The main hillock may well have been started in the late 18th century or early 19th century, when the engine shaft at Feature 1 was sunk. It would have gradually grown in size as further material was brought up the shaft, comprising both dumped waste rock, and dressing waste. It is known from documentation that the hillock was partially robbed in 1840 and reworked in 1854-56 to recover previously discarded blende, a zinc ore that was difficult to smelt until the mid-19th century. The extent to which the hillock was modified at this time, and how much its size was reduced as a result of this activity, is now not fully clear. However, it seems highly unlikely that the main hillock's footprint ever extended beyond the belland yard wall; robbing was probably confined to reduction of its height below its flat top at the engine shaft. This is consistent with interpretation of the main hillock as being mostly derived from shaft sinking and development of levels underground, with this waste later overlain by material derived from ore dressing. It was the latter that would have been targeted when previously discarded ores were reworked and this material may well have largely been removed in 1854-56.

The present surface topography of the hillock must largely reflect activity in the 1854-56 period; only the steep lower hillock side is likely to be earlier. It seems likely that the flat areas of the lower terrace at Feature 10, comprising the lower dressing floor and the access roadway in front of the 'ore bins' at Feature 11, was created immediately after this date by levelling these areas. In contrast the earlier flat platform around the main engine shaft at Feature 1 was larger before 1854-56 and may well have extended some way over this area. After the mid-1850s robbing it is likely that more material was added to the hillock from the later-1850s onwards as more underground mining was undertaken, but the quantity seems to have been small and confined to the areas where there is dressing waste at surface below the lower dressing floor on the Feature 10 terrace and at areas to either side of this.

The hillock has small amounts of clinker scattered widely across its surface, but with this mainly concentrated on the upper slope below Platform 3 and in the adjacent hollow at Feature 7. At a point on the slope immediately south of Platform 3 there is an exceptionally large lump of clinker. The character of the material present is consistent with this being from the fireboxes within the mine's steam engine boilers. Thus, it is likely that it was discarded on the hillock in its final form from the mid-1850s onwards.

10: Lower Dressing Floor

On the downslope side of Feature 11 there is a narrow flat area approached by Access Roadway 18 that in effect a continuation of this. To the south-west, between here and the upper edge of the steep lower side of the main hillock, the ground is less regular and has been robbed. There are no features that indicate ore dressing took place here; this may well be part of the robbing surface created in 1854-56 (see Feature 9). In contrast, to the south-east of the 'ore bins' at Feature 11, the flat area below Feature 11 broadens out and this may well be a dressing floor. This would have been used for the final stages of processing using equipment such as buddles, after the ore had been crushed on the upper dressing floor west of the main engine shaft at Feature 4. The hillock side immediately south of Platform 10 has much dumped material that is small in size and may well be dressing waste (see Feature 9). It may be that this lower terrace was only created after the main hillock was reworked for zinc ores in the mid-1850, with the eastern half of the robbed area flattened off to create this lower dressing floor.

11: Bank of 'Ore Bins'

This unusual feature has no known parallel elsewhere at a mine site in Britain. It is a complex stone-built structure comprising a set of vertical-sided tanks built in a line following the contour, with a high wall on the downslope side with six openings, leading into the now rubble-choked tanks behind; the downslope side of this wall, which is up to just over 3.0m high, has had its face robbed. Presumably this face was of ashlar and was taken for reuse elsewhere after the mine was abandoned; there is a low heap of discarded material adjacent to much of the length of the wall where this robbing took place. Differences in the design of the openings show that it may be a two phased structure, with four identical close-spaced openings to the south-east and two differently-built openings to the north-west, with these set further apart and slightly further back compared with the other four; this is matched by the differently-sized tanks behind the wall. There is no obvious butt-joint between the two halves of the wall and an alternative explanation also needs consideration; that they were all built at the same time, with the two larger north-western tanks functioning differently from those to the south-east.

The four south-eastern openings each have an outer and inner section, with a now-rotted wooden structure between the two. The outer sections each have vertical side walls and an arched top; the surfaces are not rendered. These outer openings are *c.* 0.75-0.80m wide and have tops that taper downwards towards the interior, where they are *c.* 0.85m high; the original height of the openings at the outer face of the wall cannot be measured because of the wall robbing here. At the interface between the outer and inner parts of the four openings there are recesses to the sides that no doubt contained the vertical parts of timber frames. At the top there was a now-rotted timber beam set horizontally for the same frames. Slots here run into the side walls for an undetermined distance and it may be that one long continuous beam ran over all four openings. The openings at the frames were *c.* 0.45-0.50m high and *c.* 0.60m wide. Beyond here, going inwards, the openings are *c.* 0.60m high and *c.* 0.60m wide, and continue through the wall to its inner face. These inner 'passages' are *c.* 0.70m long and each of the vertical walls are built of stone but with remaining traces of render covering the stonework; the roofs comprise now-rotted timber planks and beams. At the westernmost of the four openings, a fully-rotted timber here had a small metal pipe running vertically through it that is still *in-situ*.

The two north-western openings are of different design but again have outer and inner parts. The outer sections are each *c.* 0.90m wide and more than 0.75m high, with the base buried by

rubble, with vertical sides and a horizontally-placed timber lintel above (but that to the west has now rotted away). These openings appear to have been recessed into the outer half of the main downslope wall of the tanks rather than being roofed but robbing here makes this uncertain. At the inner end of each of two outer parts of the openings in the top half there is a vertical 'blocking' wall above a small inner opening. Each wall was built of stone at the top and two to three courses of brick below. At the easternmost opening the bricks are covered in render and above there is a metal pipe protruding from the stonework of this wall to the right-hand side. At this opening, at the interface between the outer and inner parts, below the visible part of the upper blocking wall there is an iron plate surrounding the small inner opening. This has a 0.14m wide horizontal top and 0.08m wide vertical sides (the bottom is buried by collapse rubble so cannot be assessed). There are four protruding bolts, two at the top and one in the upper part of each of the vertical sides; these may well have fastened a timber frame in place. To the sides, where the outer edge of the frame would have been, the stonework is rendered so that the timbers would have fitted neatly. The opening that the metal plate defines is just over 0.80m wide and at least 0.15m deep (with the lower part buried). An opening through the inner wall to the tank behind is of the same height but is only *c.* 0.30m wide. The lower half of the other of the two openings is buried but presumably there is also a plate and small inner opening here.

At the south-eastern tanks the downslope side comprises two walls running parallel to each other, matching the width of the inner and outer parts of the four openings, with a narrow gap between matching the position of the long lintel or lintels above the openings. This slot may have contained mechanisms for sluices in the openings below. The outer wall to the south-west was originally *c.* 1.00m wide when the facing was still present, while the inner one is *c.* 0.70m wide. Each of the six openings in the downslope wall had its own tank behind, although one of those to the south-east is now not clearly visible because of the rubble backfill. Parts of their vertical stone walls are still visible, but more frequently these are collapsed and/or buried in the rubble that part-chokes the tanks. In the south-eastern corner of the easternmost of the four south-eastern tanks there is surviving render on one wall face; it seems likely that all these tank walls were originally rendered.

The tanks themselves had vertical walls but only intermittent fragments of their facing stones are currently visible. Much of the lower halves of the tanks are rubble filled, while the upper parts of the walls have been robbed and/or collapsed. The walls were covered in render, fragments of which remain *in-situ*. The four rectangular tanks at the south-eastern end, with long axis to NE/SW, each have the downslope openings placed approximately central to their tank. I n contrast, the two rectangular tanks at the north-western end are each roughly twice the size of the other four, with their long axes at NW/SE, with their openings in the south-western corners.

While the openings in the downslope wall were clearly designed to access the tanks behind, and they may well have been used to bring out water and/or ore, their design raises questions as to exactly how they were used. All six openings are relatively small and, if used for taking solid material out, this was most likely gravel or sand, as larger material would choke the openings. This may have been difficult even with a very-long handled shovel or rake; there would perhaps have been need for a second person in the tank moving material towards the opening unless the tanks had sloping floors. Alternatively, the openings could possibly have been used just for inserting rods to loosen material in the tanks. The openings may well have been used to let water out, either in addition to ore removal or instead of this, for while the four south-easterly openings at least look superficially door-like rather being sluices, the gap

between the two walls above could have been designed to hold sluice operating mechanisms. The presence of render on the tank walls is consistent with water being present as this would make them watertight.

The Ordnance Survey mark this structure as '*Limekilns*' but as such their overall design would be significantly atypical. This author has previously speculated, at the suggestion of Jim Rieuwerts, that they could have been zinc ore calciners (Barnatt and Penny 2004, pp. 32, 87; Barnatt *et al.* 2003; Barnatt 2004). Neither of these interpretations can be correct, as indicated by the timber roofs inside the four south-eastern openings, the timber lintels at the two north-western tanks, and the render both on the walls of all six openings and lining the tanks behind. Clearly the tanks and openings were not designed to be in the proximity of heat. Another previous suggestion is that they were ore dressing buddles for concentrating ore (Porter and Robey 2000, p, 111), but no designs of similar character are known elsewhere and this seems an unlikely explanation.

Turning now to potentially viable interpretations, it has been suggested that they are ore settling tanks/filter beds (Porter and Robey 1972, p. 94; 2000, p, 111; Barnatt et. al 2013, p. 75; Barnatt et al. 2006). However, this interpretation does not fit comfortably with the height of the tanks, as periodic emptying them of the material being settled or filtered would have been significantly easier if they were lower in height and thus could be emptied from the top without the impediment of the high downslope wall; low settling ponds are the norm at large Peak District mines. More significantly, where they were built in relation to the two Dale Mine dressing floors is wrong; settling tanks and filter beds would have been place below the lower dressing floor so that material from the dressing in buddles or hotches on the lower floor did not have to the taken back upslope.

An alternative explanation, postulated here for the first time, is that the 'tanks' are storage bins for part-processed ore; this would also be washed here. If the bins were bouse teams for storage of undressed ores, then the render lining of the tanks is problematic in that lumps of ore tipped here would soon damage this. Thus, it seems more likely that the tanks were used for ore after it was crushed, placed here ready for dressing using equipment such as buddles or hotches on the adjacent lower dressing floor (Feature 10). The crushed material may well have been introduced into the tanks via chutes from the upper dressing floor north of the main engine shaft (Feature 4). In the case of the two larger tanks, it could alternatively be postulated that these were used for storage of concentrated ores before removal from site. However, storage here would have meant lifting the processed material from the dressing floor to fill the tanks, which would be unnecessarily labour intensive. More importantly, the presence of two surviving pipes, one in each set, in conjunction with the slot above the four south-eastern openings that is interpreted as possibly containing sluice mechanisms, strongly suggests ore was washed in all six tanks and at mines generally this would normally happen as part of the process of dressing the ore rather than after this was completed.

In conclusion, the interpretation of Feature 11 is not clear-cut but that of 'ore bins' for storing and washing part-processed ore is favoured here.

It seems very likely that the 'ore bins' were built in the second half of the 1850s rather than being earlier, as the terrace upon which they were built was probably created after the hillock was robbed in 1854-56. It may well be the 'building' shown on an 1860s mine plan showing details of the *c.* 1857-60 period (reproduced in Porter and Robey 1973, p. 172) depicts the 'ore bins' and thus they had been built by about 1860.

12: Reservoir Ponds and Belland Yard Wall
Here there are two conjoined rectangular hollows that are cut into the slope on the upslope side by about 1.5m. Between the two there is a bank that is 0.7m high, with a gap at one end that could have contained a wooden sluice. On the downslope side the ponds are retained by a *c.* 2.0m high purposefully built embankment in the western half, with the whole length of the ponds surmounted by a ruined drystone that is part of the belland yard wall (see Feature 8). The embankment in the eastern half for the most part is indistinguishable from the side of the conjoined quarry of Feature 5. However, at one stretch here there is a retaining wall, with a visible height of 1.2m; this is also part of the belland yard wall.

These two conjoined pits are the reservoirs for the boilers of the steam engines installed on the terrace below from 1854-55; it is very unlikely they date from the time the earlier Newcomen-type engine was in use, as this type of engine usually had a tank for water set high on the engine house rather than a reservoir. The ponds may well also have supplied water for dressing ore. How were they were filled with water is not clear on the ground but it is documented that they were supplied by water pumped up the engine shaft. While it could be postulated that they could also have been supplied by water from the leat for the underground hydraulic water-pressure engine of *c.* 1838 (Feature 30), it is likely this water course was in disrepair by the 1850s.

13: Pits
To the east of the mound of Feature 14, there is an amorphous pit, cutting a 'mound' that appears to be natural, which is about 0.3-0.5m deep. Further south-east there is a second small amorphous pit that is about 0.3m deep. Both may be small stone-getting features.

14: Embanked Pond with Leat, or a Mine Hillock, Wall Robber Trench and Launder Terrace
Here there is a mound that is just over 1.5m high on the downslope side. At its top there is an oval hollow, about 1.0m deep. A narrow gully runs downslope through the mound top from the pit, which runs as far as, and possibly beyond, one end of a short section of narrow terrace that possibly marks the site of a launder following the contour heading to the nearby upper dressing floor (Feature 4). There are two alternative ways of interpreting these features.

Taking them at face value, it may be that the mound and hollow are an embanked mine water storage pond with a leat leading off, that were presumably used in conjunction with ore-dressing, with water in the pond presumably fed by the leat above at Feature 20. The pond, if that is what it is, must be a relatively early feature in the sequence of development of the main mine complex around the main engine shaft (Feature 1), used to bring water to the adjacent dressing floor in the late 18th century or early 19th century, at a time before water was brought to the site via the long leat (Feature 30) that fed the underground hydraulic water-pressure engine installed in 1838. This said, the embankment for the 'pond' overlies Access Roadway 26 and thus it cannot belong to the earliest phase of activity at this part of the site.

There is a potential problem with the interpretation just given. The gully leading down from the hollow is at or very close to the site of the belland yard wall (Feature 8) and it may be a robber trench dating to when this was removed. Thus, it may be the mound and its pit are an early upcast hillock and shallow shaft (also see Features 15, 17 and 42), while the short section of terrace is for a launder for ore dressing that further west was raised above the land surface so has left no visible footprint. An undated 19th century map of Dale Mine, drawn

after the new 1860s shaft was sunk well to the north-west, shows a shaft somewhere in the general vicinity of Feature 14 (or the western part of Feature 5), but it is difficult to know how accurate this map is (Porter and Robey 2000, p. 11); it seems unlikely that there was an open shaft here at this date. The map maker, if showing old shafts, may have misinterpreted earthworks on site. The upcast heap overlies Access Roadway 26, which is likely to date to when the main engine shaft was first developed. Thus, if there was a shaft here, it is likely to date to one of the 19th century phases of activity, probably those in its first half.

15: Shaft Hillock

A well-defined shaft hillock, just less than 2.0m high on the downslope side, with a 1.2m deep shaft hollow at the centre. A narrow gully cuts the crest of the hillock to the west side; this is of unknown interpretation. The small size of the hillock indicates the shaft was only relatively shallow; it may be on the mineral vein also seen at Feature 42 and possibly Features 7 and 14 that are on roughly the same alignment, or it is at another minor mineral deposit found at surface somewhere nearby, perhaps also worked at Features 14, 17 or 19. While the date of Feature 15 is unknown, it seems likely that it was sunk early in the mining sequence, presumably in the 18th century, before extraction concentrated at the main engine shaft at Feature 1 (also see Feature 14). An undated 19th century map of Dale Mine, drawn after the new 1860s shaft was sunk well to the north-west, shows a shaft somewhere in the vicinity of Feature 15 (Porter and Robey 2000, p. 11); it seems unlikely that there was an open shaft here by this date.

16: Stone Quarry Pits

Five small, scattered, stone getting pits. Two dug were next to Access Roadway 21 and Leat 20, with that to north-west is 1.0m deep on the upslope side while the other is only 0.8m deep here. Another lies next to Access Roadway 22 and is 1.3m deep on the upslope side, with a fourth behind that cuts Leat 20 that is 0.5m deep on the upslope side. The fifth is between Access Roadway 22 and Quarry 18, and is 0.5m deep.

17: Possible Shaft Hillocks

Access Roadway 22 has two distinct bulges on the downslope side that cannot be explained in terms of its use. It may be that both are what remains of early mine hillocks, the shafts of which were filled and levelled when the roadway was created. The part of the remaining feature to the north-west is 1.3m high on the downslope side and contains far too much material to be explained as upcast from the small quarry pit on the other side of the roadway. The remaining part of the feature to the south-east is 1.5m high on the downslope side.

18: Stone Quarry

A deep hollow, with little in the way of quarry face exposed, which is a relatively large limestone quarry. On the upslope side it is about 7.0m deep. The quarry was cut into relatively thin limestone beds and the original face is buried by material that has subsequently eroded down the slope. Material extracted from the quarry was presumably dropped straight down to the adjacent lane as there is no access roadway. The date of the limestone quarries below the main Dale Mine complex (at 18, 57, 59 and possibly 56) is unknown, but these are likely to be 18th century or earlier 19th century in date. In the case of that at Feature 59 it predates the main pumpway at the mine, which is likely to have been driven in the late-18th or early 19th century. In the cases of Quarries 18, 57 and possibly 56, given the likely character of the material removed, it may be they were dug to provide construction material for the road, which is part of a turnpike road authorised in 1770 and presumably built soon afterwards.

19: Probable Mine Shaft and Hillock
Within Quarry 18 there is a mound, which is just over 2.0m high on the downslope side, with central hollow. Un-vegetated and presumably toxic surfaces on the mound suggest this feature is a waste hillock with metal ores for a shallow shaft rather than associated directly with the quarrying. It may have been sunk after a minor mineral deposit well away from the main pipeworking was found during the quarrying sometime in the 18th or 19th centuries, and perhaps the 1770s if the quarry was dug to provide stone for building the adjacent turnpike road.

20: Leat
This feature comprises a narrow channel following the contour, which has silted up in parts but elsewhere in still about 0.3m deep; to the south-east it is embanked on the downslope side. This is almost certainly a leat used to bring water to the mine dressing floor at Feature 4. At the south-eastern end the leat seems to be truncated by the downslope embankment of the mine reservoir ponds (Feature 12), although as an earthwork it fades to nothing shortly before the mounds edge. The water may have been let off downslope here to Feature 14 if this is interpreted as a mine pond; alternatively, as seems more likely, it went further south-east before turning to the dressing floor. The origin of the water in the leat is not clear, the leat may have been truncated by Access Roadway 21 to the north-west and has faded from view as an earthwork beyond here as it reaches flatter ground; or more probably it ran parallel to Access Roadway 21 at its north-eastern edge.

The leat is likely to be early in date as it follows or is cut by Access Roadway 21, which in itself is early and was later superseded. The leat also appears to be overlain by the reservoir embankment, which probably dates to the 1850s, and the leat would not have been needed from 1855 onwards as water for dressing was pumped up the engine shaft. Also, leat 20 presumably provided water for ore dressing at a time before water was brought to the site via the long leat (Feature 30) that fed the *c.* 1838 underground hydraulic water-pressure engine and dressing floor at the shaft top. Thus, Leat 20 may well date to the earliest use of the main engine shaft (Feature 1) in the late 18th century or early 19th century.

21: Access Roadway to Main Engine Shaft and Dressing Floors
This short section of roadway leads diagonally downslope from Access Roadway 24 to that at Feature 22. It is embanked by up to 0.70m on the downslope and cut into the slope by up to 0.5m on the upslope side. This access roadway serves the same purpose as Feature 22 and it was superseded by this, as the line of Access Roadway 21 is partial truncated by a slight lynchet at the edge of Access Roadway 22.

The relative chronology of the access routes to the main mine complex is in part uncertain, but it may well be that earlier and later phases can be identified. The focus of mining at the main engine shaft (Feature 1) probably started in the late 18th century or early 19th century, and the first access roadways are likely to have been added at this time. The first routes are interpreted as being Access Roadway 21 (the south-eastern part of which was also used later and here is catalogued as part of Access Roadway 22, while the north-westernmost part is catalogued here as part of Access Roadway 24). Access Roadway 21 led to the main features around the shaft, which included the dressing floor (Feature 4), with a branch at Access Roadway 26 leading to above the Newcomen-type engine house that was presumably used to bring in the engine and perhaps its coal. Later the access routes were reorganised at around the time the two Cornish-type engine houses were built in the second half of the 1850s. Access Roadway 22 then gave a more direct access to the shaft head, while a branch at

Access Roadway 23 led below the upper dressing floor and was used to take out processed ore from lower dressing floor (Feature 10). Access Roadway 24 to the top of the site was probably used to bring in coal for the steam engines in the 1850s, but also could have perhaps been used earlier for the same purpose. Alternatively, its south-eastern part was created in 1864 as part of the access roadway created to access the new shaft well to the north-west; if this is the case the central section of Access Roadway 24 would have been a continuation of Access Roadway 25 that accessed a quarry at its eastern end.

22: Access Roadway to the Upper Dressing Floor and Main Engine Shaft
This roadway leads from the gateway into the field to the dressing floor, the main engine shaft and sites of steam engine houses at Features 1-4; a branch (Feature 23) leads down to the lower part of the shaft-top complex (also see Features 21 and 26). For the most part Feature 22 is embanked by 0.5m to 1.0m on the downslope side. In the area immediately inside the gateway the downslope embankment is obscured and it seems this has been buried by an area of modern tipping that is now ill defined. There is a short branch at Feature 26 than runs slightly further upslope that is truncated by a slight lynchet at the edge of Access Roadway 22, showing the latter continued in use longer. It may well be that Feature 26 was a branch from the early access route defined to the north-east by Access Roadway 21, which as it came south-eastwards was remodelled as Feature 22.

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23: Access Roadway to the Lower Dressing Floor and Bank of 'Ore Bins'
This roadway branches from Feature 22 and leads down to the lower dressing floor of the main mine complex at Feature 10. It is embanked by up to 0.6m on the downslope side. Presumably this access roadway was primarily used to bring processed ore from the site.

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and here is catalogued as part of Access Roadway 22, while the north-westernmost part is catalogued here as part of Access Roadway 24). Access Roadway 21 led to the main features around the shaft, which included the dressing floor (Feature 4), with a branch at Access Roadway 26 leading to above the Newcomen-type engine house that was presumably used to bring in the engine and perhaps its coal. Later the access routes were reorganised at around the time the two Cornish-type engine houses were built in the second half of the 1850s. Access Roadway 22 then gave a more direct access to the shaft head, while a branch at Access Roadway 23 led below the upper dressing floor and was used to take out processed ore from lower dressing floor (Feature 10). Access Roadway 24 to the top of the site was probably used to bring in coal for the steam engines in the 1850s, but also could have perhaps been used earlier for the same purpose. Alternatively, its south-eastern part was created in 1864 as part of the access roadway created to access the new shaft well to the north-west; if this is the case the central section of Access Roadway 24 would have been a continuation of Access Roadway 25 that accessed a quarry at its eastern end.

24: Access Roadway to the Top of the Main Mine Complex and a Blocked Gateway
This roadway runs from close to the access gate from the road, where it has been truncated, probably in modern times, then rises slightly along the section flanking the limekiln complex to the north, and finally runs diagonally downslope to the top of the mine quarry at Feature 5.

To the north-west this access roadway is embanked on the downslope side, which is up to 0.8m high, while in one section the roadway itself, which is relatively narrow, lies within a 0.3m deep 'hollow-way'. At the end of this section Features 25 and 35 runs eastwards, while Access Roadway 24 runs diagonally down slope south-eastwards. It is not clear whether Access Roadway 25 was added after that at 24, or whether the first sections of Access Roadway 24 gave access to the quarry, via Feature 25, before the route to the mine complex was created. At the junction of Access Roadways 24 and 25, where the field wall kinks, there is a gateway through the wall that has been walled up and a roadway continues on the other side of the wall; this route through the wood is shown on the Ordnance Survey 25 inch to a mile map surveyed in 1878. A slight break of slope next to the old gateway across the north-western line of Access Roadway 24 may well date to when the route through the quarries was in use and could represent secondary use long after Route 24 was created. It could be that the route passing through the blocked gateway is that documented as created in 1862 to take the steam engine of 1854-55 to its new site well to the north-west of the area surveyed in 2018.

In the south-eastern section, Access Roadway 24 is terraced into the slope, with an embankment on the downslope side that is up to 0.5m high and in part is cut into the slope by up to 0.3m. The roadway terminated at the eastern end of the mine quarry and thus must have been made in conjunction with the mine complex, but why it was created is unclear from the surface evidence. It may have been used to bring steam engine coal to site from the 1850s but it is thought the coal yard was to the west side of the engine house and thus the terminal of Access Roadway 24 seems slightly inconveniently placed a little too far to the east. Access Roadway 24 may have earlier origins, created when the Newcomen-type engine house was built in the late 18th century or early 19th century; however, Access Roadway 26 could have brought coal to this engine. If Access Roadway 24 was a coal road as suggested here, then the coal must have been put into a chute to take it diagonally down to the 1850s coal yard (see Features 2-3). An alternative explanation for the south-eastern part of Access Route 24 is that it was created in 1864 when the steam winding engine was moved to a new shaft outside the area surveyed in 2018 well to the north-west. However, while this provides a direct route, it is hard to see how this would have worked in terms of moving the engine and

rubble from the demolished engine house, as the way up to the end of Access Route 24 is a steep irregular slope. It would be difficult if not impossible to bring the engine cylinder and other large engine parts this way; thus, the location of the 1860s route remains uncertain. This said, the only other obvious candidate, at Access Roadway 21 is even more unlikely as the horizontal stratigraphy here indicates this went out of use at an earlier date. Hence, it may be that Access Road 24 was used in 1864 despite its drawbacks because it was already there.

The relative chronology of the access routes to the main mine complex is in part uncertain, but it may well be that earlier and later phases can be identified. The focus of mining at the main engine shaft (Feature 1) probably started in the late 18th century or early 19th century, and the first access roadways are likely to have been added at this time. The first routes are interpreted as being Access Roadway 21 (the south-eastern part of which was also used later and here is catalogued as part of Access Roadway 22, while the north-westernmost part is catalogued here as part of Access Roadway 24). Access Roadway 21 led to the main features around the shaft, which included the dressing floor (Feature 4), with a branch at Access Roadway 26 leading to above the Newcomen-type engine house that was presumably used to bring in the engine and perhaps its coal. Later the access routes were reorganised at around the time the two Cornish-type engine houses were built in the second half of the 1850s. Access Roadway 22 then gave a more direct access to the shaft head, while a branch at Access Roadway 23 led below the upper dressing floor and was used to take out processed ore from lower dressing floor (Feature 10). As noted above, Access Roadway 24 to the top of the site was probably used to bring in coal for the steam engines in the 1850s, but also could have perhaps been used earlier for the same purpose. Alternatively, its south-eastern part was created in 1864 as part of the access roadway created to access the new shaft well to the north-west and outside the area surveyed in 2018; if this is the case the central section of Access Roadway 24 would have been a continuation of Access Roadway 25 that accessed a quarry at its eastern end.

25: Access Roadway to Quarry

This short section of roadway runs on from Feature 24 and leads to the limestone quarry at Feature 29. It is not clear whether Access Roadway 25 was added after that at 24, or whether the first sections of Access Roadway 24 gave access to the quarry via Feature 25 before the route to the mine complex was created. The date of this limeburning complex is not known, but given its character and scale, it is likely to have been in use in the 18th and/or earlier 19th centuries.

26: Access Roadway to Upper Part of Main Mine Complex

A short stretch of embanked access roadway branches from Feature 22; this is embanked on the downslope side where its steep slope is just less than 1.0m high and it is cut into the slope on the upslope side by about 0.5m. At its eastern end it now appears to stop short of the mound of Feature 14, but it may originally have run under this. At its western end it is truncated by a slight lynchet at the edge of Access Roadway 22, showing the latter continued in use longer; it may well be that Feature 26 was a branch from the early access route defined to the north-east by Access Roadway 21, which as it came south-eastwards was remodelled as Feature 22.

The relative chronology of the access routes to the main mine complex is in part uncertain, but it may well be that earlier and later phases can be identified. The focus of mining at the main engine shaft (Feature 1) probably started in the late 18th century or early 19th century,

and the first access roadways are likely to have been added at this time. The first routes are interpreted as being Access Roadway 21 (the eastern part of which was also used later and here is catalogued as part of Access Roadway 22, while the westernmost part is catalogued here as part of Access Roadway 24). Access Roadway 21 lead to the main features around the shaft, which included the dressing floor (Feature 4), with a branch at Access Roadway 26 leading to above the Newcomen-type engine house that was presumably used to bring in the engine and perhaps its coal. Later the access routes were reorganised at around the time the two Cornish-type engine houses were built in the second half of the 1850s. Access Roadway 22 then gave a more direct access to the shaft head, while a branch at Access Roadway 23 led below the upper dressing floor and was used to take out processed ore from lower dressing floor (Feature 10). Access Roadway 24 to the top of the site was almost certainly used to bring in coal for the steam engines in the 1850s, but also could have perhaps been used earlier for the same purpose. In 1862 a 'road' was made to take the 1854-55 steam engine to its new site well to the north-west, and while Access Roadway 24 leads via a now blocked gateway through the limekiln complex to the new mine, and this route is shown on a map of 1878, it seems unlikely that Access Roadway 24 was used in this way (See Feature 24).

27: Ruined Limekiln and Gatepost
The field boundary at the edge of the survey area incorporates a small front part of a wrecked limekiln, most of which lies north of the boundary. Here the pot has been robbed and the part in the boundary was the basal part of the walled facing at the kiln front to one side of the pot. The date of the limeburning complex to the north, of which this kiln is a part, is not known but given its character and scale it is likely to have been in use in the 18th and/or earlier 19th centuries.

Immediately to the side of the kiln vestige there is a gatepost set on the line of the wall; there is no remaining second post and the gateway has long been redundant and walled across.

28: Waste Heap
This small mound, which is 0.8m high on the downslope side, is either a waste heap associated with the limeburning quarries on the other side of the field wall to the north, or, more probably, it is a heap of waste material created when a road was taken through the old limekiln complex, starting at the adjacent now-blocked gateway; this was here by 1878 and was perhaps made in 1862 (see Feature 24).

29: Stone Quarry
A limestone quarry that is over 3.0m deep, with Access Roadway 25 terminating here. This quarry, which continues north of the field wall, is part of a large limestone quarry complex for limeburning, with at least two lime kilns, most of which is in the wood north of the field boundary, with the latter added later (also see Feature 27). The date of this limeburning complex is not known, but given its character and scale, it is likely to have been in use in the 18th and/or earlier 19th centuries.

30: Gully (Probable site of the Hydraulic Water-Pressure Engine Leat)
This narrow gully is up to *c.* 0.3m deep where it cuts through the strip lynchets of Feature 34. It heads downslope directly towards the main engine shaft (Feature 1), but fades as a visible feature in this direction. It is probable that this gully is at the site of the end section of the long leat that came from west of Warslow Hall (Porter and Robey 2000, p. 113), which provided the water to be piped down the main shaft to power the *c.* 1838 underground hydraulic water-pressure engine. If this is the case, then the gully would have held a wooden

launder that was for the most part set on the natural ground surface but cut into the uneven ground where the strip lynchets are crossed.

31: Stone Quarry Waste Heap
A relatively small spoil heap for a limestone quarry immediately north of the field boundary which has been added subsequent to the quarry abandonment.

32: Gully
A narrow gully running diagonally down the slope that is up to 0.3m deep and of obscure interpretation.

33: Stone Getting Pit
A small stone getting pit, up to 0.5m deep, cut into the uppermost lynchet of Feature 34.

34: Strip Lynchets and Possible Trackway
Here there are four main strip lynchets running parallel to each other following the contour, with short stretches of two to three shorter lynchets on the same alignment. For the most part all these lynchets have sharply defined tops but in some cases the bottom of these enhanced slopes are indistinct. They range between about 0.5m and 1.0m high. Not all the ground between the lynchets has been cultivated and below the second and third lynchets from the top there are long gaps where there is a gently-sloping unmodified natural slope. The date of the lynchets on site is unknown but they are of medieval-type and are most likely to date from when the population was greatest in the centuries immediately before the Black Death of the mid-14th century.

The third main lynchet down has a narrow terrace beneath it at the south-western end and this may have been an access trackway to the cultivation strips at Feature 38. However, the possibility that it is a particularly narrow cultivation terrace cannot be discounted. This route may continue in the other direction as Feature 35.

35: Possible Lynchets and Possible Trackway
A possible 0.8m high lynchet, or perhaps a natural break in slope, splits eastwards with a lower break of slope that is 0.5m high. Above there is a flat linear 'terrace' between the 'lynchet' and Quarry 29. The sloping ground below does not look cultivated and the linear terrace above may be a trackway branching from Access Roadway 24 and leading to the possible trackway at Feature 34. However, there is a gap between the two where the ground is relatively uneven and this leaves interpretation unclear.

36: Stone Getting Pits
Three small stone getting pits dug on the terrace above of Feature 37, with another at the top of Feature 38, which are all up to about 1.00m deep.

37: Break of Slope
While this feature looks like a *c.* 0.5m high lynchet beyond the downslope edge of the strip lynchets of Feature 34, the ground above and below is relatively uneven and shows no signs of having being cultivated, thus it may be better interpreted as a natural break of slope.

38: Strip Lynchets/Bank
Two parallel lynchets run down the slope below those at Feature 34 at a very different angle, running north-west to south-east; they both curve eastwards at the bottom end. That to the north-east is about 0.3m high while that to the south-west is 0.5m high. The former is bank-like in that a very low feature above the lynchet showed as a difference in vegetation colour in the parched condition on the day of survey. The land to the north-east of the two features does not look to have even been cultivated, although the strip between the two features looks to have been, as does a stripe of similar width below the south-western lynchet. Further south there are fragmentary strip lynchets, at Features 43, 45 and possibly 41. on the same alignment, which may well be part of the same cultivation layout. Here it may be that cultivation also extended north-westwards but any further lynchets may have been subsumed by the main mining remains (Features 5, 6, 7, 9). The date of the lynchets on site is unknown but they are of medieval-type and are most likely to date from when the population was greatest in the centuries immediately before the Black Death of the mid-14th century.

39: Probable Lynchet
An indistinct lynchet, up to 0.4m high, appears to define the edge of a cultivation strip between it and the top of the steep daleside; its south-western end is defined by Feature 45. The date of the lynchets on site is unknown but they are of medieval-type and are most likely to date from when the population was greatest in the centuries immediately before the Black Death in the mid-14th century.

40: Stone Getting Pit
A small stone getting pit, which is over 0.6m deep on the upslope side.

41: Possible Strip Lynchet
A sharp break of slope, up to 0.7m high, runs diagonally up the slope, which to the north-west may be subsumed under the Dale Mine features. While it is on approximately the same alignment as Features 38, 43 and 45, and thus may be part of the same medieval layout, the ground above and below is relatively uneven suggesting it has never been cultivated and thus this break of slope may be a natural feature.

42: Vein Working (Shaft Hillocks and Opencast Pits with Upcast)
A line of low mine workings following what is presumably a small vein deposit. There are four sets of features, each comprising hollows and associated hillocks. Two of these are higher than the others, with surrounding hillocks that are up to 1.3m high at the north-western mound, and 0.9m high at the other, on their downslope sides; these are almost certainly at shallow shafts. The other two hollows and upcast are slighter and may well represent surface prospecting. This 'vein' lies to the east of the main pipeworking running on a different alignment, aligned north-west/south-east, compared with the latter that run NNW/SSE. It may well be that the 'vein' workings here are relatively early and originally extended north-westwards under the main mine hillock at Feature 7. Beyond it may have extended to Features 14 and 15 where there are further mining remains that are on the same approximate line. Historical documentation suggests this vein was known from the 1850s as '*Sawpit Vein*' but its original name is unknown.

43: Strip Lynchet
A well-defined strip lynchet, up to 0.7m high, which to the north-west is subsumed by the main Dale Mine hillock. Cultivation may well have taken place above and below, although going upslope beyond the mining at Feature 42 this is far from certain. The date of the lynchets on site is unknown but they are of medieval-type and are most likely to date from when the population was greatest in the centuries immediately before the Black Death of the mid-14th century.

44: Shallow Pit (Mine Working or Stone Getting Pit)
This pit, up to 0.3m deep with an upcast heap to the east side, cuts the lynchet of Feature 43. It is not clear whether this is a stone getting pit or a trial mineral working associated with those at Feature 42.

45: Probable Headland
A short lynchet or natural feature, up to 0.7m high, runs north-west/south-east. Cultivation may well have taken place above east of Feature 39 and thus Feature 45 is effectively a headland where cultivation stopped at this end of the strip. The date of the lynchets on site is unknown but they are of medieval-type and are most likely to date from when the population was greatest in the centuries immediately before the Black Death of the mid-14th century.

46: Mine Working
Below the main mine hillock (Feature 9) to the south-east and within its belland yard wall (Feature 8), there is hollow in the waste deposits, with its floor approximately at the natural ground surface. To the south-east quadrant there is a ruined and crudely built drystone on the crest of the *c.* 1.0m high waste heap here. This feature appears to predate the main mine hillock in its mature form and may well be associated with earlier mining of 18th or early 19th century date; there are no indications that the hollow is the site of a shaft and its interpretation is obscure.

47: Possible Strip Lynchet
This sharp break of slope, which is about 2.0m high, runs under that main mine hillock at its south-eastern end. A stripe of land above looks as if it may have been cultivated and thus this may be part of the strip lynchet cultivation that exists further to the south-east and east at Features 43, 45 and possibly Feature 41; alternatively it could be a natural feature.

48: Footway Shaft and Hillock, with Probable Gin Circle
The site of this small-compass shaft, where there is now a low spread of rubble at surface, is surrounded by a now-ruined circular wall with only the lower courses present; the top of the shaft may well have been filled using material from the wall. The shaft is at the crest of a waste heap that is nearly 5.0m high on the downslope side.

On the upslope side to the north-east there is a large flat area, which on the upslope side is terraced into the slope in a curving arc that is up to 1.2m high, strongly suggesting that a horse-drawn winding whim once stood here. The probable gin site, and dumped ore-dressing waste at Feature 49, indicate that the shaft is an early feature, used for bringing ore out of the mine before it was later converted to a man-access route into the mine as workings were extended deeper to the north-west and the deep Engine Shaft was sunk (Feature 1).

This shaft went directly down to the main pipeworkings in their upper part where they are relatively close to surface. Mine sections drawn in the 1850s-60s shown the shaft was used as

a footway by this time, although when it was transformed for use in this way is not clear; this must have been earlier in the 19th century or late 18th century. It is very likely the shaft was first sunk in the 18th century, at a date before the Newcomen-type engine was installed, which was on site by 1807-11, at the main engine shaft at Feature 1.

49: Probable Dressing Floor and Dump of Buddling Waste

Above the steep natural break of slope running south-east from the Footway Shaft hillock (Feature 48), there is irregular ground with a series of sharp breaks of slope at the upslope edge that are *c.* 0.5m to 0.70m high. While the north-western and south-eastern ends of the area defined are irregular and may comprise dumped material, at the centre there are two flat-topped rectangular terraces, with a 0.3m high break of slope between them. These may well be dressing platforms given the material deposited on the steep slope below that is about to be described.

At eroded surfaces on the steep slope immediately below to the south there is a fine, orange-brown, mineral sand with small angular stones, probably dumped here after buddling of ore deposits had taken place, with these comprising natural cave deposits brought from underground to recover mineralised material. At the slope base the deposit appears to be up to *c.* 2.0m thick, but originally these may be significantly shallower with material having eroded down from higher up the slope. If the material is buddling waste, as seems likely, it must have been created in conjunction with ore dressing of material brought up the Footway Shaft in the 18th century.

50: Paths, Possible Mine Hillock and Levelled Terrace

A slight gully running diagonally down the steep slope below Feature 49, leads to the top of a short linear 'bank' that is 0.7m high, which runs across the flat terrace here. There is a second diagonal gully running approximately parallel to the north-west of the first. Both appear to be old access paths down the slope. The 'bank's interpretation is unclear but it is possible that it comprises part of a slight mine hillock with a 'central pit that is 0.3m deep. This could be a shallow shaft or it may be where the mineralised pipe deposit was found at surface (see Feature 56), although the latter interpretation seems unlikely as it is well out of alignment with the accessible pipeworking underground. The area immediately below, at the spur in the natural slope and crossed by Access Roadway 53, forms a flat terrace that has almost certainly been cut into the slope with a quarried bedrock face up to about 1.5m high on the upslope side; this level area may well have been created in conjunction with mining activity. The date of the features at 50 is not clear, but if the interpretation as mining-related is correct, then these are likely to date to the 18th century, at a time before the Newcomen-type engine was installed and when the Footway Shaft (Feature 48) was in use for bringing ore out of the workings.

51: Shaft Hillock

A small shaft hillock, up to *c.* 1.7m high on the downslope side, with central hollow at site of the shaft itself. The size of the hillock indicates the shaft was only shallow. This shaft lies close to the main pipeworkings at their south-eastern end where they came to surface but whether it is directly associated with these, as seems likely, is unclear; its date is also unknown but it could easily be placed early in the mining sequence.

52: Ruined Field Wall
A short section of ruined drystone wall, with lower courses still with visible faces, on the terrace at Feature 50. It runs from the base of the steep quarried slope above to the edge of Access Roadway 53. Here there is a squared terminal to the wall indicating there was a gateway here for the roadway. A previous suggestion that this wall was part of a coe (Barnatt *et al.* 2013, p. 75), on careful inspection of the wall and looking at historic maps, seems very unlikely. The Ordnance Survey 25 inch to a mile map of the area (Sheet IX.2), surveyed in 1878 and published in the next year, shows a field boundary following this line, coming from the top of Quarry 57 after flanking its western edge, to the wall at Feature 52, before running north-eastwards along the top of the steep daleside slope; other than fragment at Feature 52 all has now gone. This boundary wall is likely to be 19th century in date, built after the postulated mining activity at Feature 50.

53: Access Roadway to Mine or Stone Quarry Trial
This terraced roadway comes from the road to the west, rises to the spur on the daleside and then follows the contour to Feature 54 where it terminates. Near the beginning to the west a branch access roadway (Feature 55) leads off south-eastwards. Access Roadway 53 has been carefully engineered throughout and where necessary terraced into the slope. At the beginning there is now part-ruined drystone wall at the upslope side, while further east below the Footway Shaft hillock (Feature 48) there is a cut into the slope of up to *c.* 1.0m height. Beyond the main bend at the spur it has been cut into limestone bedrock on the upslope side by up to 1.5m along its full length; here the features has relatively recently been cleared of scrub making survey possible. The access roadway appears to become narrower as the destination is approached or here it may be partially buried by material spilled from above. The destination point was never developed beyond an initial quarry or mine trial and the large amount of work involved in creating the access route was wasted. The date at which Access Roadways 53 and 55 were created is far from clear.

54: Mine or Stone Quarry Trial
This small feature is the destination point of Access Roadway 53. Here on the upslope side of the roadway there is a small cutting into the limestone bedrock, which is up to *c.* 3.0m deep at its upslope edge. In front of the cutting face to the south-west side, overlying its footprint, there is a walled pack of waste stone that is up to 1.0m high. On the north-east side of the cutting a relatively large but poorly defined heap of waste has been piled at the cutting edge. It is not clear whether the whole is an aborted mine working or a stone quarrying trial. It is not usual to find a pack next to a quarry trial, which may suggests that this may be mining related; however, there is no obvious mineralisation here.

55: Access Roadway to Stone Quarry or Pipe Deposit Outcrop
An access roadway, terraced into the daleside slope, which branches from that at Feature 53 and leads diagonally downslope to Feature 56. This fell out of use before Feature 53, as indicated by a slight lynchet across it at the junction. The date at which Access Roadways 53 and 55 were created is far from clear.

56: Stone Quarry or Pipe Deposit Outcrop
A relatively large amorphous hollow in the steep daleside, up to very approximately 4.00m deep at the upslope side, is either a limestone quarry and/or the site of where the Dale Mine mineralised pipe deposit was first discovered. The hollow was probably cut into relatively thin limestone beds and the original faces are buried by material that has subsequently spilled down the slope. This area, for the most part, is heavily vegetated and it proved impossible to

survey in 2018, the base of the 'face' is covered in impenetrable scrub and it is impossible to see what is there; the approximate positions of the top and bottom of slopes have only been sketched. It is unlikely that the whole is fortuitous given the presence of an access roadway, although the possibility that extraction was never developed cannot be discounted. It is equally unlikely that the access roadway was for Quarry 57, as its face runs across any postulated extension of the route.

One of remaining uncertainties at the Dale Mine site is where was the mineralised pipe deposit first discovered; this must have been at surface and somewhere in the general vicinity of Feature 56 (also see Feature 52).

The date of the limestone quarries below the main Dale Mine complex (at 18, 57, 59 and possibly 56) is unknown, but these are likely to be 18th century or earlier 19th century in date; in the case of that at Feature 59 it predates the main pumpway at the mine, which is likely to have been driven in the late-18th or early 19th century. If the pipe deposit was found at Feature 56, then it would seem to have been found during quarrying and as mining was taking place by the 1766 at latest (DRO 2375M/63/55). However, in the cases of Quarries 18, 57 and possibly 56, given the likely character of the material removed, it may be they were dug to provide construction material for the adjacent road, which is part of a turnpike road authorised in 1770 and presumably built soon afterwards.

57: Stone Quarry

A deep limestone quarry cut into the steep daleside, which is very approximately 5m to10m deep. This is heavily vegetated and it proved impossible to survey this in 2018; the approximate position of the face has only been sketched. The date of the limestone quarries below the main Dale Mine complex (at 18, 57, 59 and possibly 56) is unknown, but these are likely to be 18th century or earlier 19th century in date; in the case of that at Feature 59 it predates the main pumpway at the mine, which is likely to have been driven in the late-18th or early 19th century. In the cases of Quarries 18, 57 and possibly 56, given the likely character of the material removed, it may be they were dug to provide construction material for the adjacent road, which is part of a turnpike road authorised in 1770 and presumably built soon afterwards.

58: Pumpway Entrance, Bolt and Waste Heap

The entrance to the pumpway level is within a vertical-sided cutting, just over 2.5m deep, defined on the north side and west end by quarried bedrock. The entrance at the west end was originally *c.* 1.5m high and *c.* 1.5m wide but it was walled up several decades ago and there is a more recent hole cut through this wall in its northern half near floor level; this has a locked gate installed just over ten years ago. The cutting appears to be an original purposefully-made feature, providing foot access to the rock-cut level, the first part of which is a trial level that was later utilised when the pumpway was started. The water from the level runs down a well-defined channel at floor level in the north half of the cutting. At the eastern end it enters a covered bolt, with drystone walled sides and top of horizontally placed slabs, which is 0.45m high and 0.50m wide.

This drain runs under a flat-topped, and in part ill-defined, waste heap. At the eastern end of this there is an exit point for the drain, with a short and shallow, vertical sided, channel leading from here to the river. The bolt exit is set in a part-ruined drystone wall built parallel to the river bank, with up to 1.6m visible height, part of which, to the south side, is still

extant. Here the south wall of the bolt remains, up to 0.65m high, but the roof and other side have collapsed.

When the pumpway was driven, which branches from a short trial level that is earlier, is not fully clear. It was certainly in use from the late 1830s onwards in conjunction with the hydraulic water-pressure engine installed in *c.* 1838, but it is very likely that it was already present and driven in conjunction with the Newcomen-type engine that was present on site in 1807-11 and may have been installed at least a decade before.

59: Stone Quarry

A limestone quarry with a floor on two main levels, with an upper face up to *c.* 6.0m high and a lower one that is *c.* 2.0m high. There are also, in part ill-defined, small waste heaps on the downslope side of the upper face. This quarry almost certainly pre-dates the Dale Mine pumpway entrance. The quarry is heavily vegetated and it proved impossible to survey most of this in 2018; where not measured, the approximate position of the face has only been sketched. The date of the limestone quarries below the main Dale Mine complex (at 18, 57, 59 and possibly 56) is unknown, but these are likely to be 18th century or earlier 19th century in date and they may relate to the construction of the adjacent turnpike road in the 1770s; in the case of that at Feature 59 it is likely to predate the main pumpway at the mine, which was probably driven in the late-18th or early 19th century.

60: Site of Building (Mine Office and/or Dwelling)

The Ordnance Survey 25 inch to a mile map of the area (Sheet IX.2), surveyed in 1878 and published in the next year, shows a rectangular building next to the river immediately north of the platform outside the entrance to the pumpway at Feature 58; the second edition of this map shows it had been demolished by 1897. The building stood within a yard that extended to the road and took in the pumpway entrance and platform at Feature 58. The site of the building, which is heavily overgrown, was not surveyed in 2018, but today there is only a small level terrace between the river and quarry. A dwelling near the river was documented as being occupied in the early 1870s and there was also a mine office somewhere in the same vicinity; one or both are likely to have stood at Feature 60.

Appendix 2: The Underground Survey Catalogue

All the passages assessed and features identified during the underground survey in 2015-16 are identified on Figures 15 and 16.

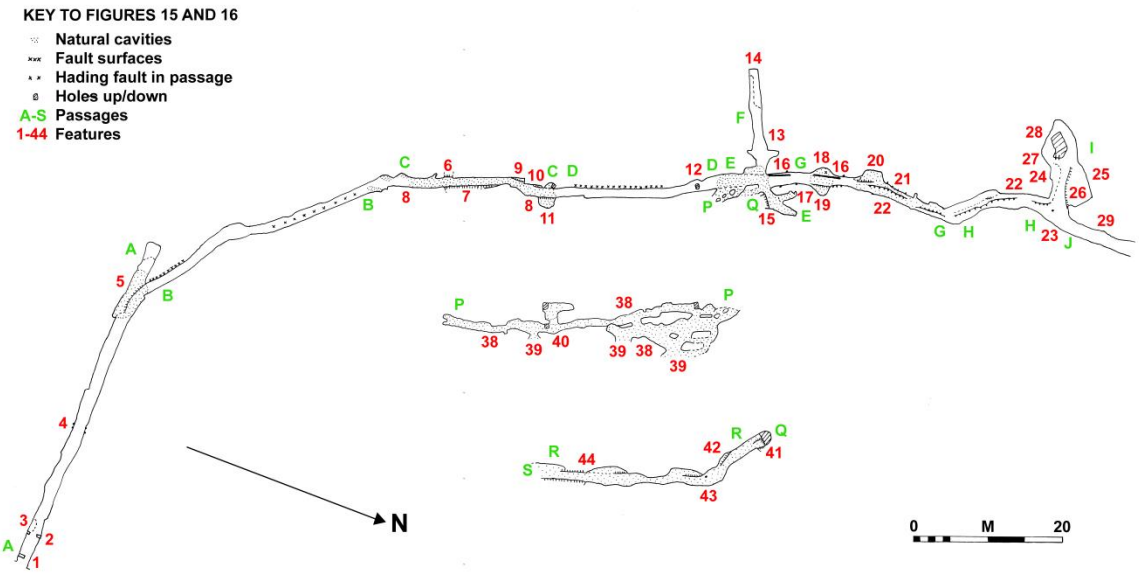

Figure 15: The archaeological underground survey catalogue numbers; south sheet (for 1-29, 38-44 see text).

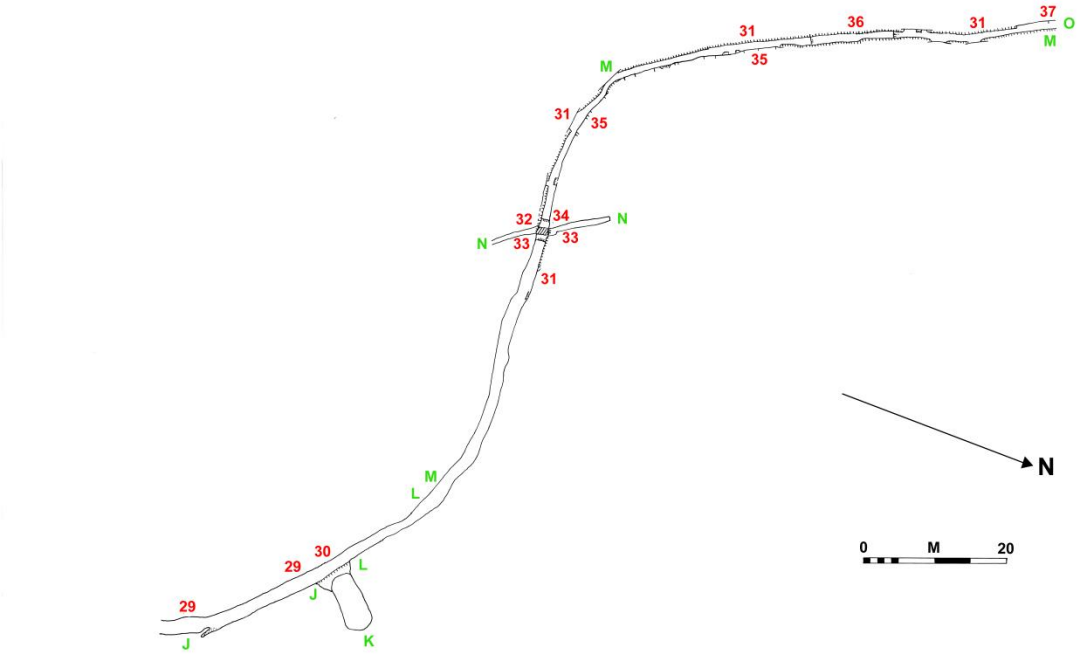

Figure 16: The archaeological underground survey catalogue numbers; north sheet (for 29-37 see text).

Passages

A: Trial Level

The first part of what became the Dale pumpway has almost certainly been driven westwards at an earlier date as a trial. It is a straight 48.5m passage ending at a benched forefield. The blasted sides and roof are somewhat irregular, with a passage width of 1.4-2.0m and the roof a little above head height. About 6m short of the forefield the pumpway (Passage B onwards) was driven off at an angle from a small natural cave cavity containing a pack of deads (Feature 5). The section from here to the forefield was partially backfilled after the pumpway was started. The trial level has shothole scars of 20-24mm diameter intermittently throughout.

B: Pumpway on Fault

The first, slightly-sinuous, 37m long section of the pumpway is driven on a fault, through un-mineralised limestone, which hades increasingly as the passage goes north-westwards; given that the passage goes through un-mineralised ground, it was presumably heading towards previously known workings (Passages C, E, P-R). Close to the end there are two small natural avens in the roof. The pumpway at Passage B has relatively regular sides and is a little over head height. It is mostly of 1.0m to 1.5m width, with one short stretch up to 2.0m wide. The passage has shothole scars of 20-22mm diameter intermittently throughout.

C: Pumpway in Natural Passage

This 21m long and 0.8-2.0m wide section of pumpway, at a slightly different orientation to the last (Passage B), is largely natural. The first section is a narrow but relatively high phreatic rift, while the passage becomes wider and less regular towards the northern end. Parts to the east side near floor level are walled off (Feature 7). A fault surface near the northern end of Passage C indicates some or all of the cave passages here started development on this line of weakness. There is a hole upwards near the end in a part-backfilled low chamber that is at least 3.5m wide, which leads to pipeworkings not far above (Passage P); nearby at the side of the chamber to the east, there is a second part-choked hole to the same workings above. No shothole scars were observed.

D: Pumpway on Fault

This slightly-sinuous 37m long section of the pumpway is driven through barren limestone following a fault and runs below the pipeworkings running above (Passage P). It is 1.0-1.2m wide and a little over head height, except at the north end where a short stretch is up to 1.6m wide and here there is hole in the roof leading up to the pipeworkings above. There are shothole scars intermittently throughout this section of pumpway, which are of 24-25mm diameter to the south and 21-22mm to the north.

E: Pumpway in Natural Passage and Pipe Deposit

This 7m long and *c.* 1.5m wide section of pumpway runs through a part-mineralised natural passage; this includes small openings to pipeworkings near the roof leading off to the east side (Passage P). A trial level leads off west (Passage F), while the natural passage leads off north-eastwards for 3m and then turn towards north and descends as an accessible passage for a further 3m, beyond which it is fully flooded. Shortly before the bend there is a small 2m long blind trial passage also running northwards. Opposite to the south there is a rise (Passage Q) leading to an upper pipeworking and footway into the mine (Passage R). No drivage shothole scars were observed.

F: Trial Level

This trial level is driven south-westwards at right-angles to the pumpway, ending at a forefield, is 14m long, 1.2-2.0m wide, and about head height at the far end where not partially backfilled. Near its start it intersected a fault with calcite mineralisation that has been cursorily trialled, but beyond here it is driven in barren ground. There are intermittent shot hole scars of 22-24m diameter.

G: Pumpway on Fault - Partially in Natural Passage

This 26m long stretch of passage in part has a pumpway profile where driven through barren limestone that is 1.2-1.8m wide and just above head height, but it also passes through two natural areas. The first is a mineralised 'vugh' that is up to 3.7m wide. The second is a natural cave passage that is 3.2m wide and relatively high; originally it was higher but there are *in-situ* clay-dominated sediments in the roof infilling its upper part. Beyond this point there is a low modified cave passage, while extending north from here the pumpway passage that follows has a natural roof at an enlarged bedding plane while the passage below is driven through barren limestone. Passage G clearly has filled pipeworkings in the floor as today water sinks at one point in the southern 'vugh' close to the northern launder (Feature 16). No shothole scars were observed.

H: Pumpway

This sinuous 12.5m long section of pumpway, driven through sloping bedding, is 1.5-2.5m wide with irregular sides, and is a little over head height. It starts on a different orientation to the last (Passage G), at first running north-westwards, then turning to the north again. At the southern end a shothole scar of 20mm was recorded, with a second in the wall at the northern end. However, here the roof also has several shothole scars of 30mm diameter driven outwards; this is presumably a later heightening of an original low section, probably associated with late modifications to Passage J as there are shotholes of the same size here.

I: Engine Chamber and Shaft

The main engine shaft lays *c.* 10.0m from the pumpway (centre to centre). Between the two is a large engine chamber in barren limestone, with irregular walls and roof, which is 11.5m long and 3.5-4.5m wide (see Fig 17). This chamber is 6.0-6.5m high, except at the far end from the shaft where there is a roof cavity and here it was originally 11.5m high, but with the bottom 2.5m filled with a walled pack to the side of an access route from the pumpway. The shaft, where it enters the roof of the chamber, is *c.* 1.8m across. At the chamber floor the shaft is significantly longer, at 3.5m long, and is 1.6m wide. Shothole scars of *c.* 24mm diameter have been recorded intermittently throughout. The chamber is known to have held a *c.* 1838 hydraulic water-pressure engine and there are numerous slots and notches for timbers, some at least may well be associated with this (see Feature 25).

J: Widened Pumpway Extension

This curved 40m long section of pumpway, which is 1.5-2.0m wide with relatively regular sides and of just over head height, has been driven through virtually barren limestone between the Engine Chamber and Shaft (Passage I) and the Abandoned Engine Chamber (Passage K). Half way along, on the bend, there is a small mineralised cavity to the east side. Where the original walls/roof of the passage remain, the shothole scars are mostly 20-22mm diameter and mostly were driven inwards. However, the southern half of the passage has been widened to the west side, with shothole scars of mostly 24mm diameter but with some of 30mm, all driven outwards; the first section is fully widened, while further north a hading side still remains. The northern half of Passage J is nearer the original narrower width, but the hading passage side has been removed near the roof, with shothole scars driven outwards

again mostly of 24mm diameter. The rock surfaces in the widened areas are noticeably clean compared with the other, older, wall that is dirty. The widening and its character are compatible with the intention to install flat rods; that this never happened is indicated by a lack of notches for support fittings.

K: Abandoned Engine Chamber

This chamber is just over 8m long, is *c.* 3.5-4.0m wide and about 6.75m high. It runs at right angles from the main pumpway to its north-east side; the chamber itself, with high roof, is offset from the pumpway by just over 1m. The chamber, which is in barren limestone, appears unfinished and has been half filled with deads (Feature 30). There is no shaft entering the roof and no sign of an associated shaft going downwards, but this cannot be discounted as the whole floor of the chamber is backfilled. The shothole scars vary in diameter, with some *c.* 24-26mm and others *c.* 30mm. Its purpose is unknown, but it is associated with the widening of the main pumpway (Passage J) between here and the main shaft chamber (Passage I), where they may well have intended to place flat-rods. The chamber is the correct shape and size for an engine of some description and no alternative explanations are apparent for a space of this shape and size. While much of the infill is 19th century in date, some has been added by the modern diggers.

L: Pumpway Extension on Fault

This 16.5m long section of pumpway is on the same orientation as the last (Passage J) and was driven in barren limestone following a fault. It is 1.2-1.8m wide with regular sides and is just over head height. Several shothole scars were recorded, all driven inwards and of 22-24mm diameter.

M: Pumpway Extension

This 126m long section of pumpway, driven through barren limestone, gradually turns to the west and then back again to the north-west; why this sinuous course was adopted is not clear. It is 1.2-2.0m wide, has relatively regular sides, and is just above head height. In the far parts the width has been significantly narrowed by modern packs (Feature 31), with the material for these derived from the dig beyond (Passage O). There are also two modern packs built across the passage that have to be crawled over. The first is at the trials at Passage N and is 3.0m long (Feature 34). The second, ending at *c.* 23m from the start of the dig, is 11.5m long (Feature 36). There are intermittent shothole scars throughout this section of pumpway, all driven inwards and of 20-24mm diameter.

N: Trials

The pumpway intersects a small vein running at an angle to it. A trial along this running to the north-west is 8.5m long and ends at a forefield. Another to the south-east is 6.5m long but ends at a collapse. Both are 0.6-0.8m wide and now no more than 0.5m high but they have deads and modern fill on the floor. In the north-western trial there are several shothole scars of 20mm diameter driven inwards.

O: Modern Dig

This modern dig along a collapsed 19th century passage extended the accessible passage by *c.* 83.5m. This length was measured in 2015 but the narrow passage was not surveyed in detail. Little of the original passage is visible, it being mostly behind metal shuttering and props used to support the dig. This ‘new’ passage was often too low to set up tripods for the survey equipment. What is visible of the collapsed material that had been dug through comprises stones in large amounts of natural clay, as normally found in cave/pipe deposits.

P: Mid-Level Pipeworking
Running a short distance above and to the east side of the pumpway there is a series of low pipeworkings, extending for 40m southwards from the northernmost entry point (in Passage E); there are a further three vertical holes down to the pumpway (in Passages C and D). The passages at P comprise a complex series of irregular interconnected and part-choked workings of crawling height, with a total length of *c.* 83.5m and widths of *c.* 0.8-3.0m. In three places to the east side there are fully choked workings, with the deads here having come from updip in short passages between here and Passage R. The Passage P pipeworkings are in largely-natural phreatic passages, in part mineralised, where the bulk of the mining seems to have comprised removal of sediments. Shothole scars do not often occur, but in three places powder was used to enlarge the passages to allow access, with scars of 20-22mm diameter; there are also occasional pickwork scars where mineral on the walls was picked.

Q: Raise
This raise from Passage E has a vertical built wall to one side (Feature 42) within a steeply rising natural passage that is over 4.5m high and it leads to the top-level pipeworking (Passage R).

R: Top-Level Pipeworking/Footway
This 34m long passage leads southwards from Raise Q and ends at a choke at Passage S, which is at the base of Footway Shaft. The passage is relatively sinuous and is largely natural, with sediments removed in part, and was used as the main footway into the mine in the 19th century. It is 0.5-2.0m wide and is of above-head to stooping height. Occasional shothole scars of 22mm diameter exist. Towards the southern end there has been a roof collapse and part of the roof here is potentially unstable; this area should not be entered.

S: Blocked Footway Shaft
All that can be seen of this feature is a pile of rubble with clay at the end of Passage R that has spilled from above. As shown by the metrical surveys of the surface and underground features, it is located at the base of the Footway Shaft, the top of which is visible at surface. 19th century stylised elevations of the mine show the pipeworking continued to ascend beyond the shaft to outcrop at surface further down the daleside.

<u>Archaeological Features</u>
1: Blocking Wall
A modern blocking wall built in brick, which has subsequently been broken through in its lower half; an iron gate has been inserted here in recent years.

2: Blocking Wall
Stub walls remain at the sides of a blocking wall that is assumed to be of 19th century date and to have contained a door.

3: Modern Heap
A small modern heap of stones at the passage side, presumably placed here when blockages were removed to lower the water level in the pumpway.

4: Roof Stemple Notches
At this point there are notches for two close-spaced roof-support stemples; there was clearly concern over roof stability here.

5: Pack
The end section of the trial level (Passage A) has been walled off with a pack of deads across the side of the natural cavity here after the passage behind was part-filled with deads once the pumpway was started. The wall rises for two thirds of the passage height and the deads behind gradually reduce in height towards the forefield.

6: Blocking Pack
A small passage on the west side of the pumpway has been walled up with a pack of deads; this was presumably a natural passage linked with those on the other side of the pumpway (Feature 7).

7: Blocking Pack and Drill Hole
A 7.5m long stretch of the east side of the pumpway has been walled up with a pack of deads; behind there is presumably a wide but low part of the natural passages here. A short distance north of the pack there is a 8cm long drill hole in the passage wall, of 22mm diameter, presumably for a wooden plug, the purpose of which is now obscure.

8: Roof Stemple Notches
Throughout the natural passage of Passage C there are notches for roof stemples at above head height. Notches for 42 pairs have been identified, often close spaced; there was clearly concern of the stability of the natural sediments in the roof.

9: Pack
A small area in a corner of the natural passages at the west side of the pumpway has a walled pack of deads that rises half way up the passage.

10: Pack
A second alcove on the west side of the pumpway again has a walled pack of deads; this is only low.

11: Packs
A natural chamber here has its sides walled up to either side of the pumpway; that to the east rises to half the height of the passage.

12: Stemple Notch
A small hole in the pumpway roof, leading to the pipeworkings a short distance above, has an associated stemple notch.

13: Backfill
Much of the trial level (Passage F) has been part-backfilled with clay and deads, with a first section that has to be crawled over, but with only a low spread extending beyond the mineralised area.

14: Forefield
The forefield of the trial level has 8 shothole scars showing the blasting pattern, with the upper part drilled roughly horizontally, while below a bench has been removed with holes drilled downwards.

15: Pack
At the base of the winze there is low walled pack of deads, which fills either an alcove or a low natural passage leading southwards.

16: Launders
In Passage G there are parts of two displaced wooden launders, leant on the passage side, which once carried the pumpway water over the filled pipeworkings in the floor; several years ago they were *in-situ* on the passage floor (Porter and Robey 2000, p. 111), but they were moved when the modern dig was taking place (Passage O), to avoid damage from footfall. That to the south is a 3m long plank, presumably from the base of the launder. That to the north is better preserved, comprising two 4m long planks at the horizontal base and one 2cm thick vertical side plank. The external width of the base is 54cm but one side plank is missing so originally it was *c.* 56cm.

In 1961 these launders were described as follows: '*Along the floor of the level for a considerable length was a wooden flooring with wooden sides. Several pieces of this were taken for the Society museum and the remains of an old sledge with iron runners was also extracted. The sledge apparently ran along the wooden floor which was presumably above the level of the water when the mines was being worked*' (Rieuwerts 1961); while the interpretation is now revised, it is clear that more remained of the launders in 1961 compared with today.

17: Launder Support Stemples
Passage G has stemples notches, five on the east side and two on the west, all close to the floor, which show that the launders were originally set on sturdy support stemples set horizontally a short distance above the floor, with the timbers probably originally at regular close-spaced interval. Further north the launder was placed on a stone plinth (see Feature 22).

18: Backfill and Stowce Saddle
The western side of the natural passage here has a low pile of deads and clay. Lying on this there is an iron strap shaped to form a stowce saddle. This has a curved central section for a stowce barrel of *c.* 30cm diameter. Beyond here the strap curves sharply back to either side and there are two straight 'horizontal' ends. The overall length is 41cm. Where the stowce was originally positioned is not known; the saddle has almost certainly has been moved from elsewhere in the workings.

19: Pack
The eastern side of the natural passage here has a pack retained with a wall of deads that is *c.* 1m high.

20: Pack/Backfill
The west side of the natural chamber here has low drystone pack wall at the pumpway edge, with a heap of material behind, up to 1m high, which shelves away again as the passage side is approached.

21: Roof Stemples
Four notches for roof stemples at the west side of the pumpway, but with no obvious cut matches on the other wall. Presumably timbers were placed across the passage here because of concern over roof stability.

22: Launder Plinth
There are intermittent survivals of a launder plinth made of stone over a 22m stretch of the sinuous pumpway passage (Passages G/H). To the north this plinth is on the west side of the passage but at the sharp bend at the junction of Passages G and H it switches to the east side to lessen the angle the launders took, before returning to the west side; further south the launder was placed on timber stemples (see Feature 17). The stone plinth is 0.20-0.30m high, with a stone flagged top in part, on which the launders from the pumping shaft were placed. The northern section is the best preserved, with five large flags *in-situ* in one section, together with a short drystone pack at the upper side propping a boulder to stop it from falling on the launders. Elsewhere there are survivals of the vertical facing for the plinth comprising a single course of stone blocks.

23: Stemple
In the centre of the passage at the junction between the pumpway (Passages H/J) and the passage to the engine chamber (Passage I) there is a stemple notch in the roof for a vertical timber that presumably went to the floor; its purpose is unknown.

24: Heap of Deads
Along the passage's southern side there is a low heap of deads, perhaps fallen from Pack 26 and moved out of the way.

25: Notches and Slots at the Site of the Hydraulic Water-Pressure Engine, Timber Floors and Other Installations
The engine chamber (Passage I) has a large number of features, found on both sides and at the east end, some or most of which are very likely to be associated with the hydraulic water-pressure engine placed here in *c.* 1838, while others may be for other installations, such as a balance bob, perhaps of earlier date. Most are notches and slots picked into the rock walls for timbers, some of which are joist slots for two timber floors part way up the chamber, others are for large machinery support timbers, and there are a variety of others where interpretation is unclear. There are also several iron pins, some with looped ends and one comprising a double staple, while others helped hold timbers in place.

The most recognisable timber notches for machinery are at the east end of the chamber under the roof cavity here; these comprise two pairs of large, close-spaced, timbers, each with notches in both north and south walls (north 19, 20, 25; south 17, 19). The two sets have their notch bases set at *c.* 3.5m and 6.3m above the chamber floor.

The lower timber floor spanned the full width of the chamber, with joist slots in north, south and east walls and was set *c.* 3.9m above the chamber floor at roughly the same height as the lower pair of machinery timbers. The western end of the floor may be marked by a somewhat more substantial timber (south 8; north 11); evidence for a continuation further west is less clear as there are convincing joist slots on only the north side, set at a slightly lower level than the floor supports further east.

The upper timber floor again spanned the full width of the chamber, but only had joist slots at the east end wall. It was set *c.* 6.6m above the chamber floor at roughly the same height as the upper pair of machinery timbers. The floor joists may well have been set in one or both of these at their west end.

Other significant features include a pair of iron bars with looped ends (south 4, 16), placed in the chamber roof on the centre line of the chamber, which were presumably for supporting machinery or hauling this into place. There are also a surviving horizontal roof beam (south 20, east 9, north 27), presumably for block and tackle for lifting machinery, and three other slots for large timbers, two at the shaft side (south 3, 6) and one further east (south 24).

Feature dimensions given below are sometimes estimates as many were out of reach and these were judged by eye. The full list of features is as follows:

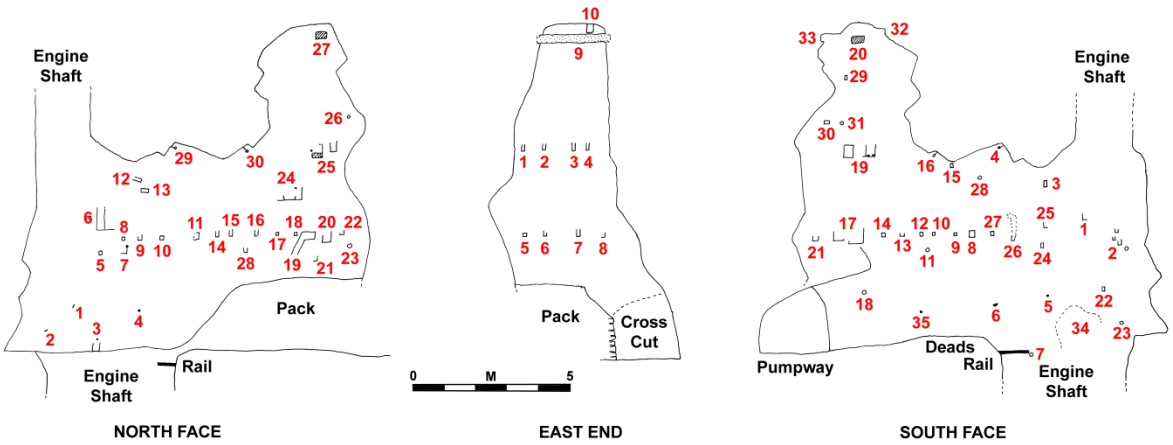

Figure 17: The archaeological underground survey catalogue numbers; hydraulic water pressure engine chamber and shaft (for 1-30 north, 1-10 east, 1-35 south. see text).

North Face

1: Iron pin that is bent sharply forward.

2: Iron staple, set at an angle, with two straight sides, *c.* 20cm long, and a top at right angles that is *c.* 10cm long. This staple is perhaps matched by eye 23 on the south wall.

3: Timber slot and drill hole for an iron pin above. The slot is for a sturdy timber that was *c.* 25cm wide and 45cm high. A potential matching slot in the north wall is obscured by deads in cavity 34.

4: Iron pin, set nearly horizontally, with a right-angled 'hook' at the end pointing upwards.

5: Timber slot for a *c.* 10cm x 10cm timber. Its height above the floor is matched by slot 7 nearby, both at a slightly lower level than slots 8-10. The only potentially matching features on the south wall are all very uncertainly interpreted (Features 24-27).

6: A long vertical slot for a sturdy timber. There is no match for this slot on the south wall.

7: Timber slot and an iron pin, designed to hold a larger timber, measuring *c.* 20x 20cm, with an iron holding pin at the top. Its height above the floor is matched by slot 5 nearby, both at a slightly lower level than slots 8-10. The only potentially matching features on the south wall are very uncertainly interpreted (Features 24-27).

8-10: A line of three timber floor joist slots for timbers that are *c.* 10cm wide. The three smaller timbers, which are placed at regular intervals, are set at a slightly lower level that those at 11, 14-18. The western floor (8-10) may not have extended to the southern side of the chamber as the evidence for joist slots here is ambiguous (Features 24-27).

11: A slot for a larger timber, measuring *c.* 20x 25cm, has an iron pin with a looped end to support one side. The top of the timber is flush with the line 14-18 and may well be the end support for this floor. It is matched by feature 8 on the south wall.

12: Timber slot that is near horizontal, *c.* 25cm long, for a timber *c.* 10cm high. If this timber was set at a slight angle across the chamber, it is matched by slot 3 on the south wall.
13: Timber slot that is horizontal, *c.* 30cm long, for a timber *c.* 15cm high. There is no match for this slot on the south wall.
14-18: Line of five timber floor joist slots. All are *c.* 10-20cm high, for timbers that are *c.* 10cm wide and one at least was also no higher than this. Also see features 8-11 and 22. These five timbers are matched by features 9-14 on the south wall.
19-20: Two large timber slots for machinery. That to the west (19) is *c.* 30cm high and 40cm long, with a long diagonal slot below for bringing the timber up into place. The timber was probably *c.* 30cm or more wide. The eastern timber (20) was slotted in from above and was *c.* 30cm wide. The two were set *c.* 20cm apart. These two timber notches are matched by two on the north side (17) and they have relatively consistent dimensions, with one *c.* 30cm square, the other either the same or somewhat wider.
21: Timber slot for a *c.* 10cm wide timber. There is no match for this slot on the south wall.
22: Timber floor joist slot, for a *c.* 10cm wide timber, at the same level as timbers 11, 14-18 and probably for a joist that supported the same floor. This slot is matches on the south wall by feature 21.
23: Timber eye of *c.* 15cm diameter. There is no match for this eye on the south wall.
24: Timber slot and iron pins. The slot base is *c.* 75cm long, with three iron pins for supporting one or possibly two timbers, one at least *c.* 45cm high. There is no match for this large slot on the south wall.
25: Two large timber slots for machinery. That to the west is *c.* 40cm wide and has wooden packing in its base to bring this level with the eastern timber. One side of the timber was held in place with an iron pin with looped end. The slot to the east is only *c.* 20cm wide but *c.* 40cm high. The two timbers were set *c.* 20cm apart. These two timber notches are matched by two on the south side (19), but here these seem to have each measured *c.* 30cm across; this miss-match may suggest the timbers were somewhat smaller than the notches cut for them.
26: Timber eye of *c.* 10cm diameter. This eye is matched on the north wall by slot 30.
27: Roof beam that is *c.* 20cm deep and *c.* 40cm wide, with a visible length *c.* 2.1m, but set in notches in chamber wall at either end so somewhat longer than the dimension given. Near either end, on the under-face there are rectangular cut notches for further timbers, perhaps suggesting this timber is a reused one.
28: Timber slot for a *c.* 10cm wide timber. This slot is matched by eye 11 on the south wall.
29: Iron pin with looped end, set in the roof at an angle, on the approximate centre line of the chamber.
30: Iron pin with looped end, set in the roof at an angle, on the approximate centre line of the chamber.

<u>East End</u>
1-4: Line of four timber floor joist slots, set at relatively regular intervals but with a wider gap to centre, all *c.* 10cm wide and *c.* 15-30cm deep, at *c.* 6.6m above the chamber floor. This timber floor is at a matching height as the large timber machinery slots in the south (19) and north walls (25).
5-8: Line of four timber floor joist slots, set at relatively regular intervals but with the widest gap to centre, all *c.* 10cm wide and *c.* 10-25cm deep, at *c.* 3.9m above the chamber floor. This timber floor is at a matching height to those on the south (8-14, 21) and north walls (11, 14-18, 22), together with the large timber machinery slots in the south (17) and north walls (19, 20).
9: See North 27.

10: Timber slot for a now missing square timber that was *c.* 20cm across, which matches that on the south face at Feature 33 and both were for a timber that ran above and at right-angles to the extant timber at Feature 9.

South Face

1: Possible slot for a *c.* 10-15cm wide timber. There is no match for this slot on the north wall.

2: Three timber slots and one eye, all in a tight cluster. The slots are all for *c.* 10-12cm wide timbers and the eye is also of *c.* 10cm diameter. There are no matches for these slots and eye on the north wall.

3: Timber slot for a *c.* 12cm wide timber. If this timber was set at a slight angle, it is matched by slot 12 on the north wall.

4: See North 29.

5: Iron pin set horizontally with a hooked right-angled end pointing upwards.

6: Drill hole for an iron pin.

7: Timber eye of *c.* 10cm diameter. There is no match for this eye on the north wall.

8-10, 12-14: Line of six timber floor joist slots. The westernmost (8) is for a *c.* 20x20cm timber, with a thin wooden plank in the base to level up the timber. The other five are for *c.* 10cm wide timbers and are relatively evenly spaced; four at least were no higher than *c.* 10cm. The larger timber (8) is matched by feature 11 on the north wall, while the five smaller timbers are matched by features 14-18 here.

11: Eye for a *c.* 10cm wide timber, matched by slot 28 on the north wall.

15: Timber slot for a *c.* 12cm wide timber. There is no match for this slot on the north wall.

16: See North 30.

17: Two large timber slots for machinery. That to the east is *c.* 30cm across, while that to the west is *c.* 50cm across; the gap between them is 8cm. These two timber notches are matched by two on the north side (19-20) and they have relatively consistent dimensions, with one *c.* 30cm square, the other either the same or somewhat wider.

18: Timber eye of *c.* 8cm diameter. Any matching feature in the north wall is obscured by Pack 26.

19: Two large timber slots for machinery, each *c.* 30cm wide and seemingly for *c.* 30cm square timbers set *c.* 40cm apart. That to the west has two metal shims to level up this timber. These two timber notches are matched by two on the north side (25), but here these seem to have measured *c.* 40cm and 20cm across; this miss-match may suggest the timbers were somewhat smaller than the notches cut for them.

20: See North 27

21: Timber floor joist slot, which is *c.* 20cm wide and placed at the same level as timbers 8-14 and probably for a joist that supported the same floor. This slot is matched on the north wall by feature 22, but here it is narrower, perhaps indicating the south wall slot was overcut.

22: Timber slot for a *c.* 10cm wide timber. There is no match for this slot on the north wall.

23: Timber eye of *c.* 7cm diameter. This eye is perhaps matched by iron staple 2 on the north wall.

24: Possible timber slot of *c.* 10cm width. This is a potential match for one of the clearer notches on the north wall (features 5, 7-10).

25: Possible timber slot of *c.* 10cm width. This is a potential match for one of the clearer notches on the north wall (features 5, 7-10).

26: Possible timber slot, comprising a long natural slot that may have been modified to take a timber of *c.* 10cm diameter. This is a potential match for one of the clearer notches on the north wall (features 5, 7-10).

27: Possible timber slot of *c.* 10cm width. This is a potential match for one of the clearer notches on the north wall (features 5, 7-10).
28: Timber eye of *c.* 10cm diameter. This eye is matched by slot 28 on the north wall.
29: Timber slot for a *c.* 10cm wide timber. There is no match for this slot on the north wall.
30: Timber slot that is *c.* 20cm wide and 10cm high. This slot is matched on the north wall by eye 26.
31: Timber eye of *c.* 10cm diameter. There is no match for this eye on the north wall.
32: Timber slot with no base for a now missing timber, which matches 33 and both were for a timber that ran above and at right-angles to the extant timber at 20.
33: This is the same feature as East 10.
34: Cavity in the chamber side, comprising an irregular recess with deads that may conceal a notch or ledge to match timber 3 on north side.
35: Drill hole for an iron pin.

26: Pack
A pack filling the northern half of the engine chamber (I) at its eastern end, which is up to 2.5m high and supported by a battered drystone wall of deads. Parts of this, and the western end of the pack, have collapsed.

27: Rails
Protruding into the side of the engine shaft there are two tramway rails of 'bullnose' type. The visible sections are 0.7m and 1.1m long and they are at a horizon just below the likely original floor level of the passage here. It is very likely that they are not part of an *in-situ* tramway, but were placed here to support a platform at the shaft edge.

28: Engine Shaft
The engine shaft, where coming from surface it enters the roof of Chamber I, is *c.* 1.8m across. At the chamber floor the shaft going to depth is longer, at 3.5m long, and is 1.6m wide; between them the shaft is waisted to one side. This difference suggests that the half of the shaft nearest the pumpway going into the floor had a special purpose; it probably held pump rods and pipes. The two rails (Feature 27) are likely to have supported a platform, allowing close inspection of what was positioned here, and there are rotting timbers at this west end of the shaft sides and at two other places, all at roughly the same level as the rails, which go with this interpretation.

29: Postulated Site of Flat Rods
The shotholes to the western side of the passage were driven outwards and are larger than those elsewhere in the passage that are driven inwards; the work was unfinished (see Passage J). It may well be that the large abandoned engine chamber to the north (Passage K), which also seems to be part of the same unfinished project, was going to be linked to the engine shaft (Feature 25) using flat rods but this was never taken through to completion.

30: Pack
The passage-side pack with drystone walled face comes relatively close to the roof but it is possible to climb this wall into Chamber K, and ascend a steep rubble slope to the far half of the partially backfilled chamber. Something like half of the chamber has been backfilled and the southern end of this is retained by the pack wall; most of the deads are original but in part these are overlain by material from the modern dig.

31: Modern Packs
In the last 100m of the long-accessible pumpway there are modern packs to the passage sides that were placed here is association with the modern dig beyond (Passage O); often they run for long distances and extend to the full height of the passage. These were one of the main ways spoil was disposed of; the other was to wash sediments away using a water pump.

32: Raise
This small exploratory raise was created to explore the small vein here at a higher level; it was not climbed during the survey.

33: Modern Backfill
The trial passages here have been partially backfilled with modern spoil from the dig at the end (Passage O).

34: Modern Pack
This packs built across the passage is 3.0m long and 0.95m high. It was built when the modern dig (Passage O) was taking place.

35: Drill Holes
A 32m long stretch of the pumpway has intermittently placed 20mm diameter drill holes in the north-eastern side of the passage, all about half way up the wall. The first pair comprises one that is 50mm long with a rotten wooden plug and another that is only short and presumably aborted. Others are 80-110mm long and one other has rotted traces of a wooden plug. What these plugs were for is not clear; options include supports for a signalling system or hooks used during drivage to hang lights. Whether the drill holes extend further down the passage could not be determined because of the near-continuous modern packs here (Feature 31).

36: Modern Pack
This packs built across the passage is 11.5m long and *c.* 1.0m high. It was built when the modern dig (Passage O) was taking place

37: Support Pin
Just short of the modern dig there is a single visible sturdy iron support pin high in the south-western passage side; it is L-shaped with the end half pointing upwards. This 'hook' is a bar that is square in section and is tightly fitted into a round drill hole of 30mm diameter; at the outer end it is bent through ninety degrees to form an upward pointing 'hook'. A line of six of these pins, supporting an '*iron bar*' was visible extending inwards before the modern dig was undertaken (Rieuwerts 1961; Porter and Robey 2000, p. 112). They were designed to support large natural boulders in the passage roof.

38: Stone Heaps
Intermittently in the mid-level pipeworking passages there are piles of stones on the floor that presumably result from sorting of sediments, with larger stone dumped close to where they came from.

39: Backfill Deads
In three places there is backfill of deads that choke ways into passages at a higher level to the east side that are no longer accessible.

40: Driven Passage Link
The short passage to the small chamber to the west has been created by miners using shotholes to link the two adjacent passages, perhaps to create a new and easier way through into the southern parts of the mid-level pipeworkings.

41: Walled Raise Side
The vertical section of pipeworkings here has a vertical drystone wall of deads, made to create a rise that was easy to negotiate, which presumably once had a fixed access ladder when the footway was in use.

42: Packs
There are three small retained packs at the top-level passage side, two rising to near the roof, which in the northernmost case is low, while the southernmost rises to 1.2 m high with unused stacking space above.

43: Vertical Stemple
An *in-situ*, short, vertically-set, stemple, placed to support the roof to the passage side.

44: Walled Passage
The section of passage near the southern end of the top-level passage, presumably including that part beneath a roof collapse, has drywalled sides, parts extending to the roof that flank the footway.

Appendix 3: Future Work

Various actions in the future are recommended:

1: The stonework at the bank of 'ore bins' (Feature 10), which are an unique structure of a type not known elsewhere at a mine site in Britain, are in urgent need of consolidation as deterioration of the remaining masonry is ongoing and parts are threatened by collapse. This would involve the following:

a) Clearance of collapse rubble at the downslope side of the main wall at the feature, with an archaeological watching brief undertaken to record both any basal courses of the original face of the structure that are currently buried and also any unanticipated features that may be exposed.
b) The extant walling throughout the structure should be repointed by a specialist builder with experience of using lime mortar.
c) Consideration should be given to emptying the stone lined 'ore-bin' pits of collapse rubble that infills their lower halves; this would aid our understanding of the feature and allow it to be better interpreted to the public. Part of the decision making process should be consideration of long term maintenance of the exposed feature; no significant issues are apparent here as long as consolidation at the time of emptying is undertaken.
d) Newly exposed parts of the feature should then be consolidated in the same way as the main downslope wall and other exposed walling.

2: Consideration should be given to undertaking archaeological excavations at the sites of the three steam engine houses and other buildings near the main engine shaft (Features 2, 3). This would be of significant benefit in understanding the site and have a positive impact on public interpretation.

3: Given the special and very unusual nature of the site, a recommendation should be made to Historic England that the Dale Mine mining remains are considered for designation as a Scheduled Monument. In support of this, this report should be passed to them.

4: That this archive report in modified form, with the Appendices removed, is published in an appropriate journal such as Mining History, to raise awareness of the site amongst historic mining specialists and to present the results of the survey and interpretation of the site.

5: That awareness of the site is raised by summary publication in easily digested form, for example in Archaeological Conservation in Derbyshire, local magazines and via the local press.

6: In addition, interpretation of the site for the general public should be enhanced. Given that the site is on Open Access land, consideration should be given to on-site interpretation boards and/or inclusion in websites that give local historic places to visit (dedicated digital guiding information that can be accessed by mobile phones is currently problematic given the lack of a mobile phone signal over much of the site).

7: That local awareness of the site, and adoption by the local community, is encouraged by a pubic talk given locally and a guided walk for the wider Peak District community. Monitoring of the site should be encouraged. This adoption could include involvement by local people, as volunteers, working on the tasks recommended in points 1 and 2 listed above.

8: In addition, a talk could be given at Derbyshire Archaeology Day (that has the whole of the Peak District within its remit), which would enhance awareness of the site to those with a pre-existing interest in the archaeology of the Peak District.

Glossary

Arch head: At Newcomen-type engines the pumping beam was often of timber rather than iron as normally used later. At both ends of the beam there was a curved end piece, known as an 'arch head', where the beam was connected by chains to the engine cylinder at one end and the pump rods at the other.

Aven: A term for a vertical passage going upwards from a cave passage.

Balance bob: A rocking beam similar to the type of beam connecting engine cylinder to pump rods, at for example at Cornish-type pumping engines. At balance bobs a large box containing scrap iron or stone was fixed one end of the beam, with the other attached to the pump rods. The balance bob acted as a counterweight, reducing the effort needed when the steam or water-powered engine lifted the pump rods, thus allowing the engine to work more efficiently.

Bargain: A miners' term for a short-term contract between specific miners and the mine management, where ore extraction work was paid for by an agreed percentage of the sale price of the ore (also see Tribute Bargain), or when non-ore producing work was undertaken, for example at levels or shafts that were being created, this was done for an agreed price per fathom.

Belland yard: A wall around mine waste heaps that prevented stock in the surrounding area grazing them and thus being poisoned. 'Belland' is a dialect miner's term for the finely powdered lead ore, while poisoned stock was said to be bellanded.

Boiler house: A building designed to hold a boiler or boilers, used in conjunction with steam engines and installed in a separate or conjoined building.

Bolt: At mines a term for a low covered drain where water from a sough or pumpway was conveyed to a river or stream.

Bouse Team: A miners' term for a stone-built container used to store ore before ore dressing; often also used for washing this. When banks of bouse teams exist, they were often used to store ore produced by different groups of miners, with a different bin used for each, so that their individual royalty payments could be determined. An alternative term 'ore bins' is normally used in this report, to prevent confusion, as the Dale Mine examples are unlikely to have been used before the dressing was started.

Brattice: A miners' term for vertically-placed boarding in an engine shaft that subdivided it into haulage and pumping parts, and sometimes also a third part with an access ladderway. Brattices could also separate a shaft from a conjoined chamber.

Breast-shot waterwheel: A waterwheel where the water used to power it was introduced part way up its edge, entering the waterwheel buckets here rather than at the top or bottom of the wheel.

Buddle: A miners' term for wood- or stone-lined troughs of various designs used to concentrate ore, where water was mixed with finely crushed ore and waste. Lead and other metal ores were heavier than the non-metallic minerals with which they occurred and thus by mixing the crushed material with water and carefully pouring this into the buddle, the lead ore settled on its sloping floor while lighter material was flushed away.

Catch pit: A miners' term for a pit or tank that water from ore dressing was fed into. This allowed the fine sediments in the water, which often contained residual ore, to settle here rather than entering the local water system.

Coe: A miners' term for a small building at a mine that was used for shelter, storing tools and sometimes to protect the top of an access shaft.

Collar: A miners' term for the top of a shaft; this was often strengthened with stonework or timber, which made access and haulage easier. Sometimes platforms across the shaft were added to make it easier to reach kibbles; often these included trapdoors that helped prevent accidental falls down the shaft.

Cost book mining company: A miners' term for a mining company where shareholders had their shares entered in a 'cost book' and agreed to fund the venture by regular calls for money when required, in return for regular payment of dividends when the mine was in profit; the shareholders were not liable for debts should the mining venture fail.

Cornish type steam engine: A type of engine introduced in the 19th century that was used for pumping, or for winding or crushing ore, which had a vertical cylinder operated by steam under pressure.

Cross-cut: A miners' term for a passage through host rock linking two or more veins or other workings. Often they went between mineralised deposits that were already known, driven to aid extraction to a focal point linked to surface. Other cross-cuts were driven as trials to search for undiscovered deposits to the sides of pre-existing workings.

Crusher house: A building that contained a mechanised ore crusher.

Deads: A miners' term for pieces of removed bedrock or mineral that did not contain enough ore for processing. Deads were discarded, either stacked within the workings or placed on surface hillocks.

Dressing floor: Dressing is a miners' term for the processing of mined ores to remove all unwanted material attached to the ores, such as rock or non-metallic minerals, so that the ore could be concentrated before sale and removal to smelters. Larger mines usually had a built working floor at surface adjacent to the engine shaft top or level entrance where the ore was processed. With some ores a preliminary task was to wash what came out of the mine to remove clay and other easily separated contaminants. After washing where necessary, two basic operations took place on the dressing floor in order to prepare the ore concentrate. Firstly, crushing the lumps of ore and non-metallic minerals brought from the mine, either by hand or with a mechanised crusher. Secondly, separating out the crushed ore by sieving and buddling.

EDM: A survey instrument that, like a theodolite, accurately measures horizontal and vertical angles, but also contains a laser that measures distance; hence Electronic Distance Measurer.

Engine chamber: Some large workings had pumping and winding engines underground, placed in purpose-made chambers. These contained a variety of water-powered and steam-powered engines, as well as horse whims and capstans.

Engine house: The building erected to contain an engine, usually powered by steam. In 18th and 19th century examples these were often impressive buildings built of stone and had an attached or nearby boiler house.

Engine shaft: A shaft that normally came to surface, used in conjunction with an engine (horse-, water- or steam-powered) for haulage and/or pumping. Such shafts are typically of relatively large diameter and deeper than shafts used to climb in and out of a mine, or internal winzes and raises; they were usually designed to bring ore and water in one vertical lift from the sole of the mine to surface. In some instances large engine shafts were partitioned and had sections for haulage, pump rods and pump pipes, and access ladders.

Fathom: A unit of measure commonly used at mines in the past; there are six feet (1.8m) to one fathom.

Fault: A geological term for a fracture or discontinuity in the rock, across which there has been displacement along the fracture as a result of earth movement. Often they go vertically or diagonally down into the ground and extend horizontally over significant distances.

Flat rods: A miners' term for a series of timber beams or metal rods placed horizontally or on slopes, linked together and used at surface or underground along levels. These were designed to connect steam engines or waterwheels, which were often but not always sited at surface, to shafts tops, where the flat rods were connected to pump rods that led down to pumps. They were also used underground, leading from pump rods to reach pumps in irregular and often sloping pipeworkings.

Footway: A miners' term for an access route into a mine used specifically by miners to reach their place of work.

Forefield: A miners' term for an underground working face, at a stope, pipeworking or level.

Gate: An alternative name used by miners for a horizontal level.

Gin circle: A horizontal circular platform, either on built-up ground or levelled into a natural slope, where a horse-drawn winding whim stood; 'gin' is a miners' term for an 'engine'. Near the gin circle's outer edge there was a circular bed where the horse walked when operating the engine. At the centre there was bearing-stone for the vertical timber axle for the winding drum above.

Hade: A geological and mining term for the inclination from vertical of a fault.

Haulage level: A miners' term for a horizontal passage through rock, or driven along a vein, which gave access to workings and allowed ore to be removed, often utilising a tramway.

Haystack boiler: An early type of steam engine boiler that was circular in shape, with a domed top and a firebox beneath rather than within the boiler.

Headframe A frame at surface above a shaft, traditionally of wood but in recent times of metal and/or concrete, which supported the pulleys for the winding rope. Frames used for a pulley for lowering pump pipes and rods into the shaft were often referred to as sheerlegs.

Hillock: A miners' term for a heap of waste material at surface, usually comprising non-metallic mineral and/or stone, either placed here as it came out of the working or dumped after it had been crushed and dressed.

Horse-drawn winding whim: A whim is a miners' term for a type of horse-drawn engine used for bringing ore, and sometimes barrels of water, up a shaft; this was placed to the side of the shaft top (see the section on 'Horse-drawn winding whims' above for a detailed description).

Hotch (or Hutch): A miners' term for a sieve for ore processing on a frame within a rectangular tank, with a pole to hand-operate it. Mechanised versions were referred to as jigs.

Hydraulic water pressure engine: An underground pumping engine, where the metal cylinder was powered by water under pressure derived from the weight of water that had been dropped into a long vertical pipe coming from above.

Jig: A miners' term for a hotch that was operated by an engine rather than by hand.

Kibble: A miners' term for an iron bucket, or iron-hooped wooden bucket, used for lifting mineral and stone up a shaft.

Ladderway A miners' term for an underground route that allowed ladder-access to workings, placed either in a shaft or a steeply inclined pipeworking or stope.

Launder: A miners' term for an open-topped artificial water channel, usually made of wood, and common on dressing floors and also underground where water needed to be carefully channelled to prevent flooding below, or to bring water to where it was to be used or disposed of.

Leat: An artificial surface water course, often designed to bring water along a contour to where it was needed.

Level: A miners' term for a horizontal passage through rock, or driven along a vein, which gave access to workings and allowed ore to be more easily removed.

Mine agent: A person appointed by mine owners who oversaw the running of a mine and the sale of ores.

Newcomen-type steam engine: An early type of steam engine, named after Thomas Newcomen one of the main inventors of these in the early 18th century. At mines, they were often placed in tall engine houses that contained the main cylinder, which was operated only by the weight of the cylinder piston top under atmospheric pressure. All early Newcomen-type engines at mines were used for pumping but in the last three decades of the 18th century Newcomen-type engines used for winding were also introduced.

Ore bin: A miners' term for a wooden tank or stone-lined container used for holding part-processed or processed ore.

Ore house: A miners' term for a small building used to store ore, often after it had been dressed and was ready for sale; these helped protect the ore from theft.

Pack: A miners' term for a carefully placed heap of waste rock retained by a drystone wall of stone and/or non-metallic minerals.

Phreatic cave: A geological term for caves formed while completely full of water, with dissolution of the limestone occurring in all directions rather than gravity-determined flowing water. The term 'phreatic' is also used to describe distinctive rock surfaces within such caves.

Pickwork: The distinctive linear scars on rock or mineral surfaces left in underground passages where a miner's pick has been used.

Pipe: A miners' term for an ore deposit that often lies roughly horizontally or runs irregularly rather than being vertical and following a fault. In some cases what miners called pipes comprised ancient cave passages that had been filled or part-filled by mineralised deposits, either at the time of mineralisation, or by the re-deposition of eroded alluvial sediments that contain ore in caves that post-date the mineralisation.

Pipeworking: Mined cavities in a pipe deposit.

Pitwork: A miners' term for the timbering placed in shafts, particularly at landings, cisterns and brattices, but also including iron pump pipes, pump rods of iron or timber, and ladderways.

Pumping beam: A substantial rocking beam of timber or iron with a central pivot, which was connected at one end to a pumping engine cylinder and at the other to pump rods.

Pumping engine: An engine, powered by steam or water, which was used to pump water out of a mine in order that workings did not flood.

Pump pipes: A miners' term for large cast iron pipes used to bring pumped water up shafts or pipeworkings. In deep shafts there were several sets of these, each referred to as a 'lift', with one set placed vertically above the last; between each lift there were cisterns and pumps. Similarly, in long sloping pipeworkings there were also several lifts.

Pump rods: A miners' term for iron or timber rods placed in shafts or pipeworkings, connected to steam- or water-powered engines at surface, with pumps placed below that were located both at the bottom and at cisterns placed at intervals up the shaft or along a sloping pipeworking. In some cases iron pump rods were placed within the pump pipes.

Pumpway: A miners' term for a horizontal level, usually just above the water table, where water could be removed from the working in the same way as a sough, but where water had first been pumped from deeper in the workings. However, miners often used the terms sough and pumpway interchangeably.

Raise: A miners' term for an internal shaft within a working that has been driven upwards.

Shale gate: A miners' term for a level driven through shale to access mine workings; in the Peak District these workings were usually in limestone.

Shothole: A distinctive drilled hole made by miners into which gunpowder (or later high explosives) was placed in order to remove rock and mineral by blasting.

Sough: A miners' term for a horizontal level at the sole of a mine driven specifically to drain those parts of a working below the natural water table.

Stemple: A miners' term for a piece of wood, or less commonly stone, wedged across a working or vein. These were used for supporting stacked waste rock placed above or to one side, as roof and working platform supports, and as rungs in ladderways. Often they were set into rock walls in picked circular notches or rectangular slots.

Stowce: A miners' term for a hand-drawn windlass used to being ore up a shaft.

Stope: A miners' term for the space left when vein mineral has been removed, creating a vertical but relatively narrow working that was sometimes many metres in length and height. The act of creating stopes is known as stoping.

Strip lynchet: An archaeological term for narrow terraces used for cultivation, that often follow the contour, each separated from the next by an artificial break of slope known as a lynchet; the later often comprise a lower half cut into the natural slope with made-up ground above. These lynchets were created in the first instances to provide relatively level ground to either side, and then enhanced as cultivation proceeded.

Sump: A miners' term for a downward extension at a shaft, below where the lowermost levels led off, made in order to collect water and keep it out of the workings until it could be cleared by pumps.

Tramway: In the context of mines such as Dale Mine, an underground level with rails of wood or iron, where ore and waste rock was moved along the rails in wheeled wagons; these would have been pushed by hand and the gauge was narrow.

Tribute Bargain: A miners' term for a short-term contract between specific miners and the mine management, where ore was extracted, raised and dressed in return for an agreed percentage of the value of the ore.

Turnpike road: A toll road of 18th and 19th century date, built by investors following being granted a Parliamentary Act that allowed its construction.

Vugh: A geological term for cavities in vein and pipe mineralisation. They vary in size from millimetres to tens of metres and frequently contain crystals that have grown from the walls into the centre of the cavity.

Waggon boiler: A steam engine boiler, that was elongated in shape, with parallel sides, a domed top that gave it the appearance of a covered waggon, and a firebox beneath rather than within the boiler.

Waterblast: A miners' term for a method of ventilation used from the 18th century onwards that entailed dropping water down a pipe in a shaft in such a way that air was forced out at the shaft base. Here the air was directed into further pipes that led to areas of the working in use where there was insufficient air flow.

Winding engine: An engine that was steam-, water- or horse-powered, which usually was used for bringing ore and/or waste stone up a shaft; sometimes water was brought up in barrels.

Winze A miners' term for an internal shaft within a working that had been sunk downwards.

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