The Ecton Mines 1880s Dressing Shed Archaeological Evaluation Excavations - November-December 2015

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Abstract: Archaeological work has been undertaken in advance of conserving and partially-rebuilding a large 1880s dressing shed wall at the Ecton Mines. This wall is terraced into the steep hillside at the eastern edge of a large mine hillock. The flat top of the hillock was used as the main dressing floor for Deep Ecton Mine from the mid-18th century, and also for Clayton Mine from the early 19th century, until both mines closed in 1889-90. The 5m high wall supported the rear of the roof of a large open-fronted shed within which ore was processed. There were three openings through the wall for ore chutes but not water, which was previously thought to have also been introduced into the building here from a pre-existing stone-lined drain behind the wall. These chute openings had timber lintels and as these rotted the walling above had collapsed, in one instance within the last 20 years.

There was archaeological supervision as the old rubble collapses in front of the wall were removed. This recorded previously unexpected extant raised floors with ruined flanking walls in front of two of the chutes. Excavations behind the central and southern chutes found unanticipated stone-lined ore hoppers of exceptional size, larger than any comparable surviving structure elsewhere in the Peak District. Both hoppers had complex stepped timberwork at their floors, sheathed with wrought iron sheeting at the chute itself, with timber 'raking boards' behind in the hopper bases; there were indications of now-removed doors between the two components. The northern chute was found to be different to the other two, with a simple sloping timber floor. Trial excavation showed that a comparable hopper to those at the other two chutes did not exist; it was beyond the scope of the funded project to undertake extensive deep archaeological excavations here to determine what the original form and function was of what lay behind. A delay for such work was not compatible with the conservation and rebuilding schedule; any such investigation is for a future date.

These discoveries have added to, and modified, our understanding of how ore processing was undertaken in the 1880s at the Ecton dressing floors. Finding the two large ore hoppers and the conservation/rebuilding of these and the three ore chutes, has added visually-interesting and impressive features to the site. They allow future visitors to have a better understanding of the ore-dressing process during the last phase of mining.

Introduction

The site: The main Deep Ecton and Clayton Mine dressing floor, centred at SK 0972 5818, lies above the valley bottom at the same contour as Salts Level, which is sited along the hillside a short distance to the north. Most, but not all, of the visible features date to the 1880s when this ore processing area was last used during the final phase of mining at Ecton.

The dressing floor, which is a key component of the Ecton Mines, was interpreted in some detail during a recent English Heritage (now Historic England) recording project (Barnatt 2013, pp. 33-36); The dressing floor and other parts of the Ecton Mines are a Scheduled Monument (National Heritage List No: 1021175).

The dressing shed's back wall reported here lies at the eastern edge of the flat hillock-top dressing area. Before conservation and rebuilding, it comprised a high wall, oriented north/south, in parts standing to its approximate original height at just under 5m, with three collapses where there were once ore chutes that are spaced along its 23.3m length.

The dressing shed interpretation prior to 2015: It is known from documentation that the wall ran along the back of a large dressing shed built in the 1880s (Porter and Robey 2000; Barnatt 2013); details of the surviving historic record for the building are given below.

When surveyed in 2008 and then assessed against the historic record, it was postulated that the three chutes allowed both ore and water to be introduced into the dressing shed, with the ore washed in the chutes or hoppers behind before being dressed below inside the shed. It was suggested that the ore was coming from the south along an extension of the tramway running behind the engine house, with water provided by a 1780s stone-lined leat coming from the north, which here was buried behind the wall; after excavation we now know that while the ore came through the chutes, the water needed for the dressing process employed must have come into the shed via a different route, presumably coming through the north wall of the building directly into the interior of the building.

In the English Heritage publication report it was suggested that there may have been now-buried stone-lined ore hoppers behind the high wall (Barnatt 2013). A superficially similar example exists at Tankerville Mine in Shropshire where there are six well-preserved and partially restored stone-lined ore bins in a high wall which date to the 1870s-80s (Shaw 2009, pp. 133-40). Shortly before the 2015 excavations took place doubts about this interpretation had arisen. Collapses at two of the chutes, which took place over the winter of 2013/14, had revealed the tops of timber uprights immediately behind the chutes. These did not fit comfortably with ore bins of the same type as at Tankerville and raised the possibility that rather than

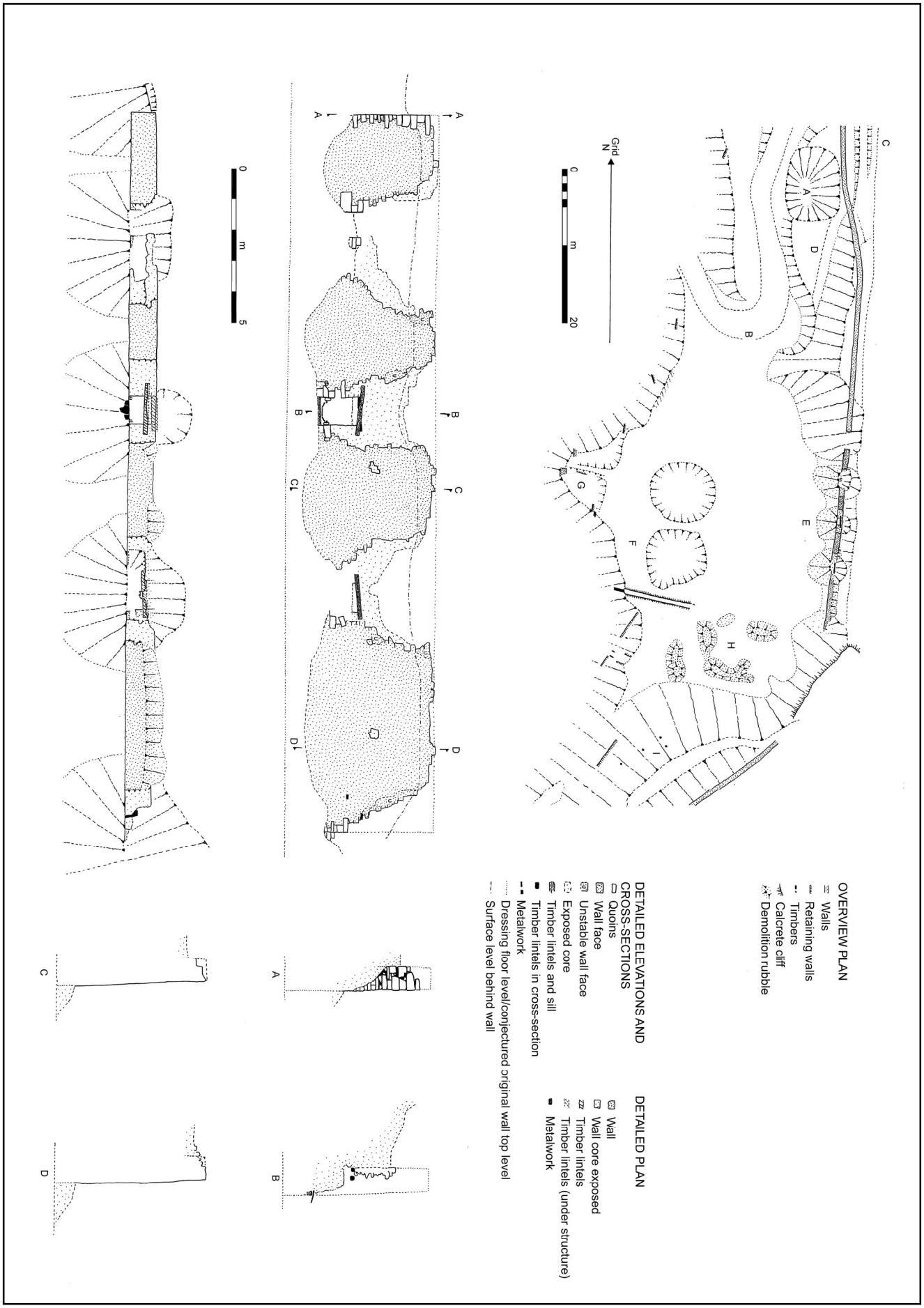


Figure 1: The main Ecton dressing floor and dressing shed wall as recorded in 2008 (after Barnatt 2013, p 34). A: Site of Old Smithy Shaft, B: Site of New Smithy Shaft, C: Buried 18th century stone-lined water leat, D: Site of early 19th century tramway from Salts Level, E: The 1880s dressing shed back wall, F: Hollows at sites of 1880s circular buddles, G: Hollows at sites of robbed 1880s slime pits, H:, site of 1880s engine house demolished in the 1920s.

Plate 1: The dressing shed back wall in 2015, shortly before conservation and rebuilding work started.

stone-lined ore hoppers, there was originally some form of timber chute for the ore, bringing it down to the line of the stone-lined drain.

This uncertainty made it imperative that excavation of one of the hoppers took place before conservation and rebuilding of the wall was undertaken to try and understand how ore and water were introduced to the dressing shed. Following the excavation, we now know that neither previously postulated interpretation was quite correct: there were stone-lined ore bins, but these were significantly larger than those at Tankerville, with internal timbers which are thought to have strengthened doors between bins and chutes; there was no provision for introducing water into the bins directly from the stone-lined channel, which at this point must have been disused by the 1880s.

The conservation and rebuilding project: English Heritage instigated conservation work at the dressing shed wall to arrest ongoing deterioration; by providing a grant to the landowners to undertake conservation of the structure, to include rebuilding of the collapsed stonework above the three chutes.

As a preliminary to this conservation and rebuilding work, a large number of trees, saplings and shrubs on the dressing floor were felled in spring 2015. The archaeological work was undertaken in November and December 2015, and various tree stumps in the ruined parts of the wall and immediately behind it were carefully removed. The restoration work was ongoing into Spring 2016.

Plate 2: The dressing shed back wall in 2015, shortly after trees had been felled.

Two main archaeological tasks were undertaken:

- A watching brief as heaps of rubble in front of the wall were machined away, to ensure no intact archaeological structures were damaged and to record anything exposed;
- Archaeological excavations in and behind the three chutes to investigate how ore and/or water were introduced to them.

Large hoppers were found behind the central and southern chutes and these were excavated and recorded. In contrast, no hopper was found behind the northern chute.

The building work was originally scheduled to take place in September 2015 but, because of delays beyond anyone's control, the start date was put back until mid-November. Inevitably the weather in September was glorious, while in the period when the work was carried out the sun was never seen and rain was frequent. This had the effect of making excavation slow and unpleasant, and the cleaning of surfaces for recording was challenging; taking good quality photographs proved impossible because of poor light levels and smeared surfaces.

The Known History

The dressing floor - pre 1880s: The large hillock present today south of Salts Level has been in existence for over 250 years and its top has traditionally been used for processing ore. Over the 150 years of use it undoubtedly grew inexorably larger whenever material was processed here or waste from driving levels and sinking shafts was dumped. Such work was largely continuous in the 18th century and more intermittent in the 19th century, ceasing in 1888. Dressing had been carried out from the 1750s at the latest, perhaps starting a decade or two earlier. The floor and its plant were periodically revamped, including a major overhaul in 1804-07 when Salts Level was created and another from 1884 when the last ambitious mining at Ecton was undertaken.

When the floors were first created, ore was brought from the main Deep Ecton level via Old Smithy Shaft (see Fig. 1), probably in use until 1769, then replaced by New Smithy Shaft nearby which was used to 1806 when Salts Level was finished, and reused again briefly in 1860. Buildings in use at different dates before the 1880s included dressing sheds, a 'shaft house', a smithy, and an 'engine and boiler house' that was presumably for driving dressing equipment. There were also rectangular 'buddles' (tanks of probable rectangular form for ore concentration) and 'sludge pits' (settling tanks commonly known to miners as 'slime pits'). For a fuller account of the pre-1880s dressing floors and their use see Barnatt 2013.

The dressing floor - 1880s: The Ecton Company Ltd was formed in late 1883 with the aim of reworking the Ecton Mines. Their initial priorities were to reopen Clayton Mine and also to work Waterbank Mine and link this with the Clayton Adit in order to de-water this mine at the far side of the hill and provide a better route for bringing the ore to surface. A longer term aim was to also work Deep Ecton Mine, but while Deep Ecton Level and Salts Level were put in good order and trials made above the flooded workings, pumps had not been installed to facilitate work at depth by the time the company went out of business in 1889-90. With these aims in mind, new dressing plant was installed, using the

pre-existing dressing floor site along the hillside to the south, at the same level as Salts Level.

Much of the information given below is extracted from the frequent summary reports on progress given to shareholders in the Mining Journal; relevant reports are given in the bibliography. These accounts are included here in some detail to provide a context for the development of the dressing shed and its associated equipment for the relatively short life of this late-19th century initiative, and for the interpretations of these remains that follows below.

In October 1884 Bowman, the mine manager, wrote in the Mining Journal that 'Today I am offered a complete Cornish crushing mill, jigger and two round buddles with attachments, delivered on rail for £ 160, which are well worth the money, and I advise their purchase at once' and 'we shall require effective dressing machinery quite as soon as such can be erected'. It is not known at what mine this equipment had previously been installed. In early November 1884 it was noted that 20 tons of the crushing mill was at the railway station (presumably at Froghall) and by the middle of the month most of the crushing and dressing plant was at the mine, but little was done over the winter because of severe weather. Bowman wrote 'It is thought best that this erection should be located upon the old Ecton Dressing floors about equidistant from the mouths of Salts, Dutchman and Clayton main adits'. This plan was executed in 1885.

In mid-March 1885 Bowman wrote 'I am this day commencing foundation work for the erection of the crushing mill and grading down the mountain side to connect the Clayton deep adit with the dressing works'. Also in March 1885 a report by Kitto, the mine's consultant mining engineer, stated the dressing machinery 'is of the most modern type and although second hand is equal to new', but he advised putting completion of the dressing floor on hold and to concentrate on finding ore deposits. At the end of the month Bowman observed 'we are clearing ground for crushing and dressing plant and are burning lime for erections but I shall suspend work in this direction at the end of this week'. However, stopping installation never happened and in mid-April he wrote 'I have put down foundations for the crushing mill and am putting up parts of the walls to receive the machinery now on the ground, while in mid-May 'The heavy parts of the Cornish crusher are placed on their foundations'. In August it was noted that the dressing plant installation was progressing and building the inclined tramway coming up from river level was underway; this was an impressive inclined trestleway that allowed ore tubs to be hauled up from the entrance to Clayton Level to the ore processing floor. In early September 1885 Bowman observed that 'The trestle bridge over the Duke's gravel pits is completed and the excavation nearly so'. The dressing floors were also nearly ready and he was hoping Robey and Co would soon finish the equipment that they were manufacturing; the main item was presumably the steam engine for the incline. By the middle of the month the new engine and machinery were nearly all delivered on site and in late October 1885 the dressing floors and plant were nearly completed but they were awaiting a few parts.

In October 1885 it was noted at the AGM that there were large stocks of Blende which they hope to soon start processing. Bowman believed that 'they shall not have much difficulty' separating the blende and copper ores. The copper was said to have contained a little less iron than some copper ores, and the blende was the finest he had seen except that from Minera in North Wales. In early November he wrote 'We have commenced 'grating' the ore and are training some boys at the picking tables but for the present our progress is slow and our patience will be fully taxed before we are able to do a days work in a day' for 'In treating these ores by machinery we are on entirely new ground'. They were also held back by the stormy weather and the short hours of daylight, and were still awaiting parts to bring other plant into use. Near the end of the month 'we have kept one set going in the grating shed, under some difficulty from the severe frost, and are learning to separate the stuff pretty well. Since starting I have made some addition to the classifiers in the mill with the object of more completely catching the copper slime. The fine copper mixed with blende is very tender and friable and will to some extent break from the granulated blende in passing through the revolving screens'.

In January 1886 the first sample of blende was sold to Messrs Vivians of Swansea for £ 3 9s per ton, while at the beginning of February they had passed ore stuff from Clayton Mine through the grating shed' and were to 'prepare it for the mill, but the severe weather at present prevents our finishing any ore for market'. A month later they were continuing to use the 'picking and grating shed' but still awaiting better weather to finish dressing. In late May they had dressed about 40 tons of poor copper ore picked out from the blende deposits from Clayton Mine and on the floors they were currently dressing blende. At the end of June the dressing floors were 'partly employed' with ores from Clayton. They had just sold 40 tons of low grade copper ore at an average of £ 2/2/6 per ton and there was 40 tons of very good blende 'in the bin' ready for sale. They were then processing a small amount of copper of better grade than the last. Near the end of July they were dressing ores from various development works and the 'Clayton stope'. They had sold 50 tons of blende, and were preparing a parcel of copper and also parcels of copper and blende slimes 'which we are now dressing satisfactorily by an adaptation of the old dolly tub'. Also they had a good pile of lead ore which Bowman was saving until he had a 'week's crushing for the mill, as it will require a complete clean up of the lighter ores.' In mid-September 'Most of the ore sent to the dressing floors during the month has been from development works which have kept our small staff of men and boys fully employed'. They had sold 25 tons of copper and had 50 tons of blende ready and 10 tons of lead was nearly ready. They needed to supplement the reservoir water with a steam pump fetching up water from the river. By mid-December they were again dressing blende and had 50 tons of blende and 20 tons of copper ready for sale. However, at the end of the year the severe weather meant that only the picking grates could be used.

In early February 1887 they had 60 tons of blende prepared, in two parcels, and were working on lead again. Later in the month the first parcel of blende had been sold to the English Crown Spelter Company and other parcels of blende and copper had also been sold. By early March they were working on lead again. However, in April they had turned to work on the slimes and two parcels of blende, and were completing delivery of copper ore sold to Messrs James Keys and Co. In May they were preparing 40 tons of blende and a parcel of slimes. By mid-June 1887 costs were being kept to a minimum by reducing the workforce of the dressing floors and employing only one man and six boys. By the end of the month they were completing delivery of copper sold and were soon to start on blende, and in late July 60 tons of blende was sold to Swansea Vale Company. In contrast with year before, this summer the reservoir provided sufficient water for their needs at the picking tables and buddles. In August they were again dressing lead, the last mention of dressing this mineral, which was sold to J. H. Moore, followed by dressing Clayton's copper and blende into September. The copper went to James Keys and Sons. By early September they were again dressing copper and blende. In December there was bad snow, but the picking grates were being used for sorting the copper and blende.

In mid-January 1888 it was noted that the copper from deep in Clayton Mine 'jigs very well', while bad winter weather in February again allowed only 'rough grating and picking'. At

the beginning of April the weather was still poor but blende was going into the ore bin. By mid-month they had 30 tons of blende sent for sale and they were preparing copper. By late May they had sold 30 tons of copper and were now preparing 20 tons of better grade ore and early in June this was sold in parcels to Neville, Druce and Co and to James Keys and Son. By late June there was another 20 tons of copper ready for sale, with more being prepared and they were dressing blende, some of which at least was from deep in Clayton Mine. By late July they were cleaning the blende and dressing copper. In early August they were cleaning the floors and were to sample 20-25 tons of copper and then dress blende. Late in the month copper was delivered to Mr H Baxter and by early September blende was sold to Swansea Vale Spelter Co and more copper was being prepared. A parcel of copper was ready in late November and was sold early in December to Neville, Druce and Co, Llanelli.

Although the totals stated are not complete, only 195-200 tons of copper ore, 240-300 tons of blende and 10 tons of lead ore are noted as prepared and sold in the Mining Journal texts. These amounts were very poor considering the financial investment made.

The company secretary, J. Goldman, wrote of the mining company in July 1888, that they 'have not, as they were led to expect, either large quantities of blende, left behind by former workers as not being worth the cost of sending to market, at the then prices of the mineral, and their expectation of finding a continuation of the ore pipe in depth has been altogether disappointed' (Chatsworth Manuscripts - Devonshire Collections - Uncalendared).

They largely stopped mining and dressing activity in December 1888 and the directors agreed to wind up the company at the May 1889 AGM, with Goldman appointed liquidator. At the end, on the 3rd Feb. 1890, he published a statement 'For two or three years before the Mines were purchased, enquiries were made, every scrap of information which could be obtained was hunted up and the few old people who could be found who were acquainted with the old workings were interviewed, with the result that very confident anticipations were formed that large profits would be obtained from the ores left standing when the water had been pumped out. The Company, after taking possession, vigorously set to work and, at a great expenditure of time and money, unwatered the Mines, only to find that what they had been led to expect did not exist and that it was necessary to commence and carry on systematic mining operations in different directions. Towards the middle of the year 1888 it became manifest to the Directors that if the mine was to be further developed, more capital would have to be provided.'

After the landlords, the Duke of Devonshire (Devonshire Liberty) and Captain E. U. Blackett (Burgoyne Liberty), refused to reduce the rents substantially, 'such want of liberality' led parties to be so 'dissatisfied with the conduct of the Landlords that they refused to assist. As they alleged, to put money into the Lessors' pockets'. In winding up the Company, the mine equipment was put up for sale and an offer of £ 550 was taken. Of this, a sum of £ 545 went to the landlords for rent, including 'the £ 5 and £ 10 respectively allowed, an exhibition of meanness for which I think it would be difficult to find a parallel'. Only'£ 5 was left to pay the expenses incurred in bringing up the pumps and rails out of the levels, making good the surface, and other incidental expenses with closing the Mines'.

The company's London solicitor was freer with opinion than Mr Goldman, in his letter of 20th Nov 1889 to Curry, Holland and Curry, the Duke's solicitors, and published alongside the Feb 1890 statement. 'The Leesors have now been paid the utmost farthing the law would allow them to claim. No doubt they were entitled to insist upon their strict legal rights. No one ever disputed the right of Shylock to claim his full pound of flesh, but unless the Legislature interferes to put a stop to such high-handed proceedings on the part of greedy or poverty stricken Landowners, one great branch of industry which is being fast crushed out will be wholly lost to this country.' 'The landlords have killed the goose, but they have not found the golden egg'.

The 1880s dressing floor structures: Two photographs of the floors taken in the 1880s show several features here (Porter and Robey 2000, pp. 2, 90).

At the southern end of the floors there was a two-storey engine house of a type suitable for a horizontal engine, which was used for bringing the tubs up the incline from the Clayton Level entrance and also presumably for driving a variety of other plant on the dressing floor such as the crusher, jigs and two circular buddles. There were two small metal chimneys towards the eastern end of the hipped roof with skylights. The large trestled inclined tramway came to the top of the incline from Clayton Mine, levelling off at the first-floor level of the engine house, behind it to the south. There must have been a continuation of the tramway, not visible in the photographs, going from here round to the ore hoppers behind the dressing shed, the bed for which was either rubble-built but has subsequently collapsed, and/or was on a timber trestle. In front of the engine house there was a small steeply-inclined timber-trestled inclined tramway for ore tubs, with one visible in the photograph, which had wheels that were larger at the bottom end and smaller at the top. It ran between the main dressing floors and an opening into the engine house at the main tramway level. Water was fed into the engine house via a pipe at roof level, presumably for use in the boiler and coming from the Dutchman Level entrance, where water still runs today.

The 1880s photographs also show the crusher house, which was attached to the western end of the engine house. It was a long, single-storey, building which at the north side was open-fronted to the dressing floor. Nothing can be seen of what lay inside, but the Mining Journal reports mention classifiers, comprising revolving screens, as well as the crusher.

The east side of the dressing floor was taken up by a large dressing shed; this was the subject of the 2015 investigations and wall conservation/rebuilding, and is described in the next sub-section.

There were two circular buddles to the west side of the floor, the sites of which can be seen today as shallow circular hollows; rescue excavations at one of these in 2002 recorded a timber base for its central cone (Barnatt 2013, pp. 34-36). The photographs show they were of typical circular buddle design with revolving sweep arms over a cone attached to a central support post.

Behind the buddles, further west and not shown on the 1880s photographs, there were the pits for settling slimes mentioned in the Mining Journal accounts, only small parts of which survive today as the rest were removed when the hillock was robbed in the 20th century. A photograph thought to have been taken in 1906-07, put alongside what survives today, shows that there were at least three rectangular walled 'slime pits' (Porter 2002, p. 74; Website - Staffordshire Past Track, Ecton Copper Mine; viewed 14 Dec. 2015).

Other dressing equipment existed; one of the 1880s photographs shows what is almost certainly a free-standing rectangular hand-operated hotch with handle above, placed out in the open close to the southern circular buddle. Similarly, one Mining Journal entry mentions that dolly tubs were used for processing slimes; these could have been placed near the slime pits, or perhaps in the dressing shed.

The 1880s photographs show that ore was moved from one part of the floor to another on narrow-gauge tramways in relatively small tubs.

Water for ore-dressing was supplied using the contour leat leading for over 1.5km from the east side of the hill via Apes Tor to the north; the stone-lined channel installed in the 1780s was still in-situ in the 1880s. The reservoir was put in good order in the summer of 1884 and presumably the stone-lined drain was cleared of silt by lifting its cover slabs; the exception is that part that ran behind the 1880s dressing shed that was never reopened.

The accounts of 1880s mining operations in the Mining Journal mention several times that processed ore ready for sale was stored in 'ore bins'; these are very unlikely to be the hoppers behind the dressing shed wall which were for ore to be processed. The location of the bins is obscure but it seems likely they were somewhere towards the northern end of the dressing floor, conveniently sited for access from the mine office and saleroom just north of Salts Level, and from the cart track here that led down to the river.

The 1880s dressing shed: The 1880s photographs show a large building with monopitch roof, with a front of one-storey height but with an exceptionally tall back because of the width of the building. The southern part of the western side was open-fronted, estimated at two-thirds of the length of the building. There are six bays, each divided by what look like brick columns or vertically-set timber beams rather than cast-iron columns. The northern section of the front was walled, and we now know from excavation that the northern end-wall of the building in its lower part at least was walled in stone.

Prior to the 1880s, there was a long building on the same site, presumably used for a similar purpose but with different and earlier types of ore-dressing equipment inside. This earlier building is shown on maps of 1809, 1818 and 1854 and was narrower but somewhat longer than what replaced it (Barnatt 2013, pp. 225, 235).

Exactly when the Ecton Company Ltd building was started is unclear, but this was almost certainly in 1885. It was referred to as the 'Grating Shed' and the 1880s reports refer to 'grating' and the use of 'picking tables', while they also note that a 'jigger' was bought in 1884 although where this was sited is unclear. Water was used for the grating. The ore was crushed wet for in September 1887 it was noted that 'an accident to the small pump which returns the water to the crushing mill will delay us a couple of days'. Whether any further equipment, such a 'dolly tubs' or 'hotches', was also placed in the shed is not known.

The dressing floor - post 1880s: The west side of the large hillock on which the dressing floors were sited was being robbed for stone from the 1890s through to sometime in the mid-20th century. Much of this was done by the Leek and Manifold Light Railway Company who used the stone as ballast from 1902 when railway construction was taking place and soon afterwards they also shipped it out to be sold as hard-core across the district. This stopped in 1934 when the line closed, however, others continued the trade for several years sending the hard-core out by road. The flat dressing floor area on the top eventually had its westernmost parts removed, from the 1930s, with much of the slime pits and part of the crusher house site lost.

In the area that remains the most radical change was the removal of the engine house, with the stone used by Mr Radcliffe, a local MP, in the late 1920s and early 1930s to build his home, now known as 'The Folly', sited close to the entrance to Salts Level. The piles of rubble still present today are not footings, but discarded material dumped as the building was being taken down.

Photographs taken in the early 20th century show the dressing shed back wall, with all three chute openings intact but the rest of the building gone, and a roofless engine house standing to full height, but with little else remaining above ground level (Barnatt 2013, p. 268; Porter 2002, p. 75, 77; Website - Staffordshire Past Track, Ecton Copper Mine; viewed 14 Dec. 2015); exactly when the roofs and the support pillars of the dressing shed were removed is not known, but they may well have been taken shortly after the mine closed and had almost certainly gone when the site was photographed in 1906-07.

All these photographs show the dressing floor devoid of trees; the same was largely true in the 1970s; photographs in the BGS archive taken in 1973 show only a scattering of saplings, and a few larger trees, on flatter areas near the road and on the dressing floor top (Images P222192 and 222193). Those felled in 2015 had become established in the second half of the 20th century, with the species mix indicating that some at least were deliberately planted, although many younger birch saplings were self-set.

The 2015 Excavations

The dressing shed walls (Figs 1, 2, 3): The wall as a whole is 23.3m long near its base and just less than 5m high. The western face comprises roughly-coursed to random, lime-mortared, masonry. It has limestone quoins at the ends and at the sides of three chutes spaced at relatively regular intervals along it. Before restoration there were traces of a thin skim of render across the face as a whole, which remained in patches along its length; in parts this obscured the stonework behind. Both sides of the wall are noticeably battered and the wall is *c.* 1.1m wide at the base but *c.* 0.8m at the top.

We know from the excavations that much of the fill between the wall and the natural slope was introduced in the 1880s to backfill the walls foundation trench and provide a base for a raised tramway behind the retaining wall. There is also an upper layer behind the chutes, where natural scree post abandonment has eroded from above to fill former voids.

At the northern end of the wall it is joined by the remains of a much slighter wall defining the northern end of the building. At the southern end, beyond a butt joint with quoins, the wall continues; only a 1.3m length of this was exposed during the 2015 work, but it is assumed it was built as a rendered retaining wall for the scree behind to the east, which helped support a tramway above coming from behind the engine house to the south and leading to the ore hoppers. Its current height at the front face was up to *c.* 1.0m and a back face was visible to *c.* 1.45m height; how tall it was originally is unknown. The butt joint only starts *c.* 0.8m up the wall, indicating the masonry to either side is contemporary, both built in the 1880s.

The southern chute and ore hopper (Figs 3, 4; Plates 3-5): This chute opening in the wall was originally 0.89m wide and *c.* 1.50m high at the wall face. The sides at the wall front had partially collapsed, while at the back both sides remained to lintel height.

The top had pitch-pine lintels and two remained, the back one was partially in-situ but was rotten and had broken with only the two ends remaining, while the one in front of it was also rotten and had slipped downwards to the north side, with the northern end missing. The back lintel was originally *c.* 1.70m long and 0.18m high, which although degraded shown clear signs that it was once had a rectangular cross-section. The front one was similar, was 0.15m high, and clearly rectangular in cross-section. Both were set on thin chock stones. Originally there may have been four lintels.

The bottom of the chute had a timber sill set flush with the wall which was 0.95m long and 0.12m high; there was a complex timber structure at the floor of the chute. To the east there was

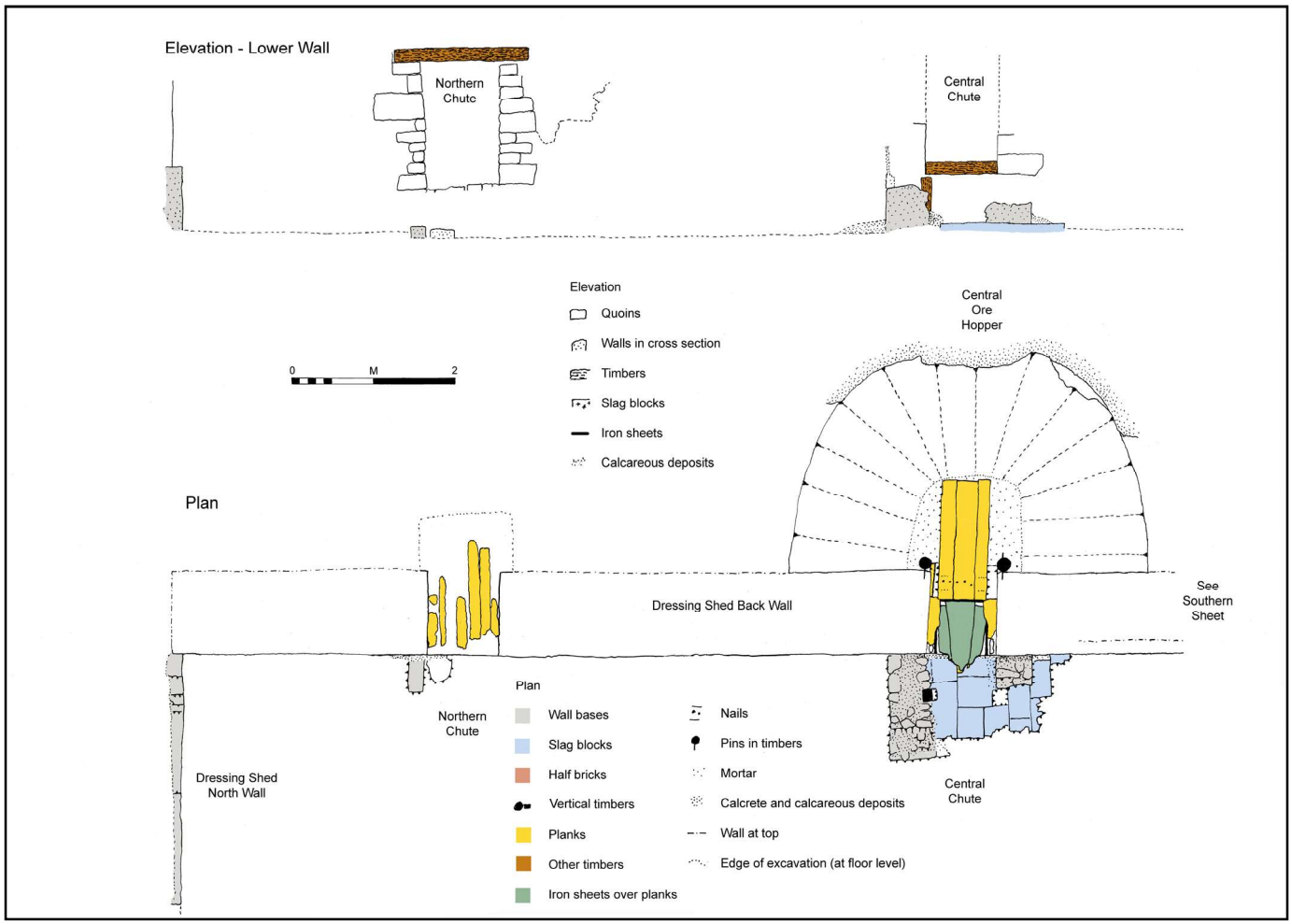
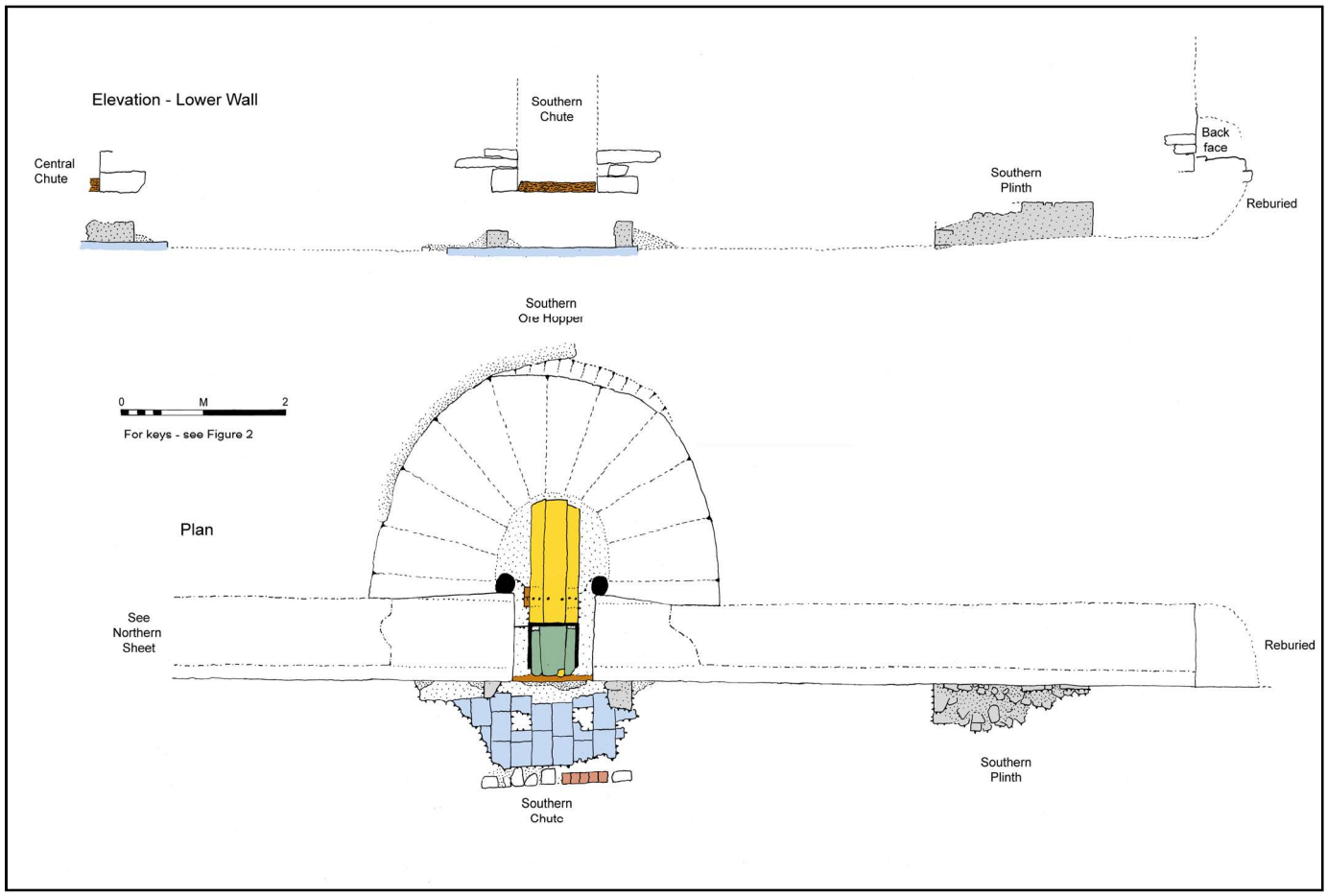


Figure 2: (above) The dressing shed wall - north.

Figure 3: (below) The dressing shed wall - south.



a sloping but flat-topped 'raking board' at the base of the ore hopper, set at about 11 degrees from horizontal, with a mortar floor to either side. The 'board', which was 1.52m long and 0.63m wide in total, was made up of three planks of different widths, all with an original thickness of 35mm, but looked at in section from the west it could be seen that the central area here is worn from use to only *c.* 25mm thick. Near this end there was a line of sturdy hand-made iron nails where the three planks have been fixed to a beam beneath. This beam could be seen to the north side where it protruded; it measures 0.15m across and 0.10m deep. When these boards were lifted to be replaced with a newly reconstructed chute, it was found that the planks overlay a second beam near the top end of the 'raking board'. By analogy with the central chute, where the shovel board passed through the first half of the chute opening in the wall, it may well have been flanked by a short, horizontal beam to either side; at the southern chute these had gone, but spaces compatible with this interpretation remained.

To the west, at the lower half of the chute there was an open-ended box, which stepped down from the 'raking boards' by 0.27m and was 0.61m wide, defined by vertically-set *c.* 35mm thick boards. To either side, by analogy with the central chute, there were once raised plinths capped with horizontal planks similar in character to those used for the box sides; at the southern chute these had not survived. The floor of the box was defined by three planks, each surmounted by a *c.* 5mm thick wrought iron sheet. These were set so that the chute continues to drop westwards at *c.* 11 degrees. The two side planks/sheets of the chute were also set at a gentle angle dropping down from the sides so that it had a gentle U-shaped profile. At the southern chute the planks/sheets of the lower chute had rotted away just inside the line of the wall face. However, we know from the central chute that it is likely to have protruded into the room by *c.* 0.60m.

Just behind the chute opening, against the inner face of the main wall, there were two near-vertically-placed pitch-pine posts with circular cross-section, both leaning slightly away from the chute sides at their tops. They were set 0.15m into the mortared base of the hopper close to the sides of the 'raking board'. That to the north was 0.12m in diameter, but becoming somewhat bulbous at the bottom, what remained rose 0.47m above the base of the chute lintels, with a sturdy iron pin through the post that protruded between the top of the back lintel and the now missing stonework above. The post to the south, as surviving in 2015, was a little shorter and had a diameter of 0.11m.

These posts were set within the ore hopper. This impressive semi-circular feature measures 4.25m across north to south against the main wall and is 2.60m wide on the east/west axis. It has steeply sloping sides of lime mortared, randomly laid, limestone blocks and less regular stones. To the east and north-east the upper side is formed by in-situ natural calcrete (comprising scree stones that have been cemented with calcite). This is very hard and was cut to the shape of the hopper side when this was built. The hopper is 2.45m-2.60m deep to the north/south sides, rising higher to the east where the calcrete has been cut.

Against the dressing shed back wall, at floor level inside the building, there is a complex structure with raised floor, ruined flanking walls and two post holes (now reburied). The floor comprised 0.05m thick slag blocks laid tightly in nine rows to form a flat surface. This slag-block floor has a straight edge just over 1.00m from the wall, but with now-ragged corners and ends. As is usual with slag blocks, they are brittle and have fractured because of frost damage and/or heavy treatment. It is unclear how far the floor once extended to the sides, but to the north it still runs at least 0.45m beyond the flanking wall. In front of the floor's front edge there was a low line of stones and half-bricks, forming a structure that was *c.* 0.25m wide and only as high, at most, as the floor top. It was unclear if this was a damaged sill or whether a narrow wall once extended higher than the floor. To either side of the chute opening there were vestiges of flanking side-walls, that to the south now standing 0.30m above the floor; how high they were originally is not known. Within the slag-block floor there are two sub-rectangular postholes, which by comparison with the central chute remains, held timber posts set *c.* 0.8m apart, centre to centre, that supported the end of chute where it originally extended into the building.

The fill of the hopper, had an upper layer that comprised an orange-brown clayey-sand with many small stones, while the lower fill was very different. This was *c.* 0.45m thick to the south side and *c.* 1.00m to the north, and comprised many angular limestone deads of small to large size within a grey sandy soil; occasionally the stones had shothole scars. Within the fills, against the back of the chute, there were four displaced timbers. Both fills had been deposited after the chute fell out of use. In contrast, coating parts of the lower chute sides and floor was a thin skim of grey sand which contained occasional small stones with blue/green copper mineral, which dated to its period of use.

The central chute and ore hopper (Figs 2, 4, 5; Plates 6-9): This chute opening is very similar to that to the south just described. It was originally 0.88m wide and *c.* 1.50m high at the wall face. Again the sides to the front of the wall had partially collapsed, but at the back both were still extant to lintel height.

The top originally had pitch-pine lintels and one remained. This was at the back and was in-situ but was rotten and had broken with the southern part slipped downwards and only timber fragments remaining at the chute side, the rest having rotted. It originally was 1.50m+ long, 0.15m high and 0.18m broad and although degraded showed clear signs that it once had a rectangular cross-section. A second rotted lintel was recovered from the heap of collapsed material in front of the chute; this again had an original rectangular cross-section. Originally there may have been four lintels.

The bottom of the chute had a timber sill which was 0.86m long and 0.15m high; there was a complex timber structure at the floor of the chute comparable to that in the southern chute, but slightly better preserved. To the east again there was a sloping but flat-topped 'raking board' at the base of the ore hopper, set at about 11 degrees from horizontal, with a mortar floor to either side. This board, which was 1.61m long and 0.62m wide in total, was made up of three planks of different widths with an original thickness of 35mm, but looked at in section from the west it could be seen that the central area is worn from use to only *c.* 25mm thick. However, at the east end the planks were much thicker at 0.08m. Near the west end there was an irregular line of sturdy hand-made iron nails where the three planks had been fixed to a beam beneath. This beam could be felt to the south side; it measured *c.* 0.13m wide and was 0.04m thick. If it conformed to the southern chute, the planks would have overlain a second beam near the top end of the 'raking board'. Where the shovel board passed through the first half of the chute opening in the wall, there were well-defined vertical-sided beam slots for lost horizontal beams to either side. That to the north was 0.44m long, 0.11m wide and 0.17m high. That to the south, which was set deeper, was 0.45m long, 0.13m wide and 0.21m high. The beam to the north side was surmounted by the broken remains of a plank nailed to the adjacent vertical upright post; presumably both sides had planks originally.

To the west, at the lower half of the chute there was again an open ended box, which stepped down from the 'raking boards' by 0.27m and was 0.61m wide, defined by vertically set *c.* 0.035m thick boards. To either side, there were raised plinths, with stone packing and capped with horizontal planks similar in character

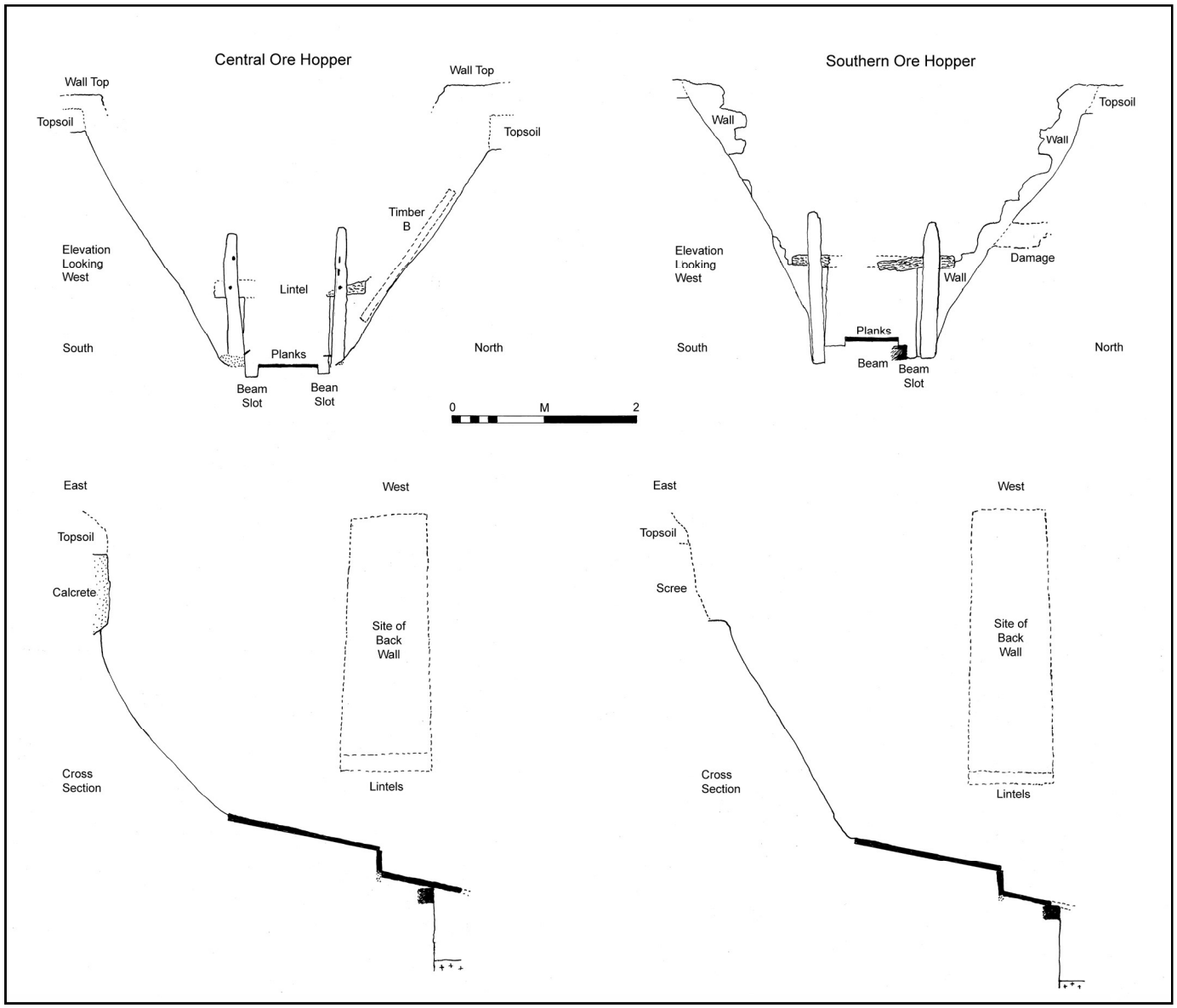


Figure 4: Elevations and cross sections of the central and southern ore hoppers.

to those used for the box sides; both planks had partially rotted away to the west end, but to the east were intact and overlapped the box by 0.03m. The floor of the box was defined by three planks, each surmounted by a *c.* 5mm thick wrought iron sheet. These were set so that the chute continued to drop westwards at *c.* 11 degrees. The two side planks/sheets of the chute were also set at a gentle angle dropping down from the sides so that it had a gentle U-shaped profile. At the central chute the planks/sheets of the lower chute had rotted away at a point 0.28m inside the building. However, we know from the position of the posts here at the floor below that the chute protruded into the room by *c.* 0.60m.

Just behind the chute opening, against the inner face of the main wall, there were two near-vertically-placed pitch-pine posts with circular cross-section, both leaning slightly away from the chute sides at their tops. That to the north was 0.12m diameter, but somewhat wider at the bottom at 0.14m, what remained rose 0.67m above the base of the chute lintels, with a sturdy iron pin through the post and fixed into the back lintel. Two nails further up, bent and hammered flush to the timber, perhaps once fixed planks here. A nail lower down the post fastened the plank running westwards at the side of the chute to the post. The post to the south had a diameter of 0.13m, what remained in 2015 rose 0.67m above the base of the chute lintels, and again had a sturdy iron pin through the post, fixing it to the back lintel. Near the post top was a nail with a fragment of attached timber running horizontally towards the north post. A nail lower down matches that in the other post that fastened the plank running westwards at the side of the chute.

These posts were set within the ore hopper. This impressive semi-circular feature measures 4.40m across north to south against the main wall and is 2.70m wide on the east/west axis. It has steeply sloping sides of lime-mortared, randomly laid, limestone blocks and less-regular stones. To the east the upper side is formed by in-situ natural calcrete. This is very hard and was partially cut to the shape of the hopper side, done when this was built, but at the centre a boss has been left which protrudes by *c.* 0.20cm, and this runs slightly further down the hopper side than those parts to either side. The hopper is 2.35m-2.45m deep to the north/south sides, rising higher to the east where the calcrete has been cut.

Against the dressing shed back wall, at floor level inside the building, there is again a now-reburied complex structure with raised floor, ruined flanking walls, a vertical post and a matching second post hole. The floor comprises 0.05m thick slag blocks laid tightly in six rows to form a flat surface. This slag-block floor has a straight edge at 1.00m from the wall, but with a now-ragged corner and southern end. The blocks were again brittle and have fractured because of frost damage and/or heavy treatment. It is unclear how far the floor originally extended to either side, but to the south it still runs at least 0.45m beyond the flanking wall. To either side of the chute

Plate 3 (top left): The southern chute after removal of one timber lintel and exposure of the displaced timberwork behind.

Plate 4 (centre left): The southern ore hopper photographed shortly after the fills and vertical timbers had been removed.

Plate 5 (bottom left): The slag-block floor, wall stubs and postholes in front of the southern chute.

Plate 6 (top right): The central chute, with ore hopper behind, photographed shortly after the fills had been removed, but before this material was removed from in front of the wall.

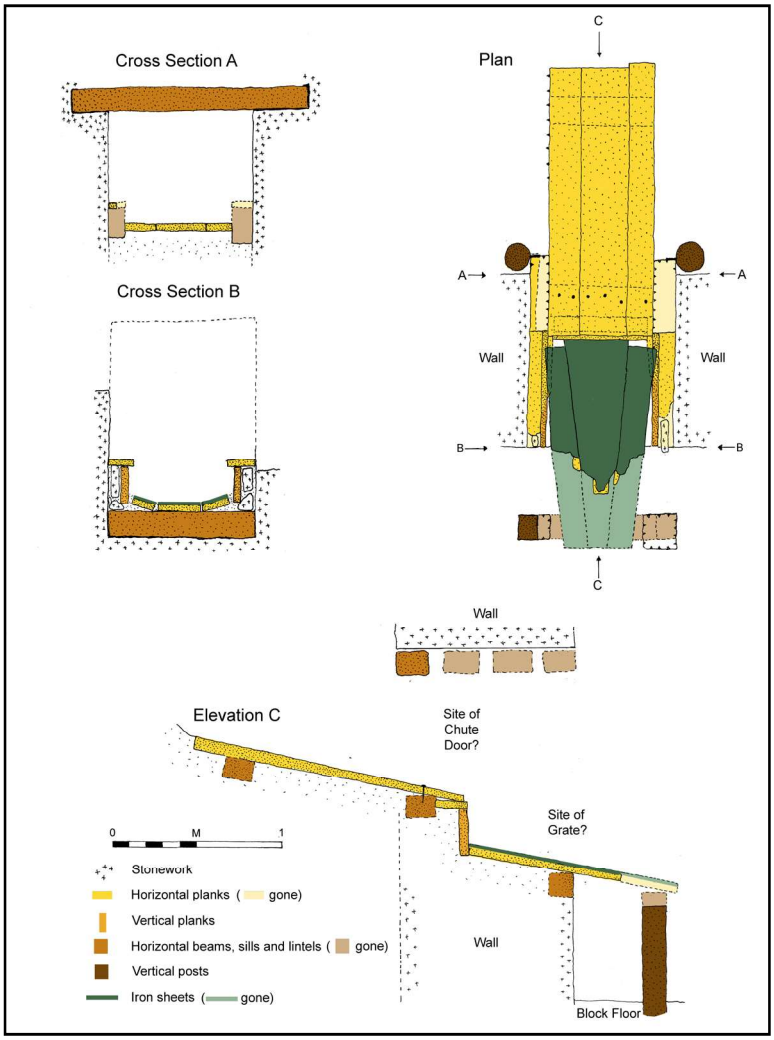


Figure 5: The central ore chute, with raking boards and postulated sites of a door and washing grate.

opening there were vestiges of flanking side walls, that to the south now standing 0.28m above the floor while that to the north is *c.* 0.50m; how high they were originally is not known, but a skim of mortar rising up the northern wall by a further *c.* 0.50m may indicate the wall was at least *c.* 1.0m high. In front of the floor's front edge the northern side wall turns for a short distance, suggesting there was similar structure to that at the southern chute that was *c.* 0.25m wide and of unknown height. Within the slag-block floor there are two sub-rectangular postholes, one at the time of excavation containing a post set at the inner edge of the northern wall. This was rectangular in section, 0.10m by 0.16m across, and rose to 0.56m above the slag-block floor. The posthole on the other side of the chute no doubt contained a similar post, with them set *c.* 0.90m apart, centre to centre, together supporting the chute.

The fill of the hopper, had an upper layer that comprised an orange-brown clayey-sand, with many small stones, while the lower fill in the bottom *c.* 1.40-1.50m was very different. This had many angular limestone deads of small to large size within a grey sandy soil; occasionally the stones had shothole scars. Within the fills, against the north side of the hopper and close to the back wall, there were two displaced timbers. Both fills were placed after the chute ceased to be used. In contrast, coating parts of the lower chute sides and floor there was a thin skim of grey sand which contained occasional small stones with blue/green copper mineral, which dated to the time the chute was in use.

The northern chute (Fig. 2; Plates 10-11): This chute opening was almost identical to the other two and originally was 0.85m wide at the bottom, 0.88m wide near the top, and just over 1.5m high at the wall face. Both sides, from front to back, were intact up to lintel level.

The top had pitch-pine lintels and two remained, the back one was in-situ and one in front of this was rotted and had broken/slipped to the north side; a third rotten example was found displaced in the collapse rubble in front of the chute. The back lintel was in relatively good condition, was 1.62m long and 0.16m diameter, its cross-section was circular and there was in-situ bark at one end; it was never rectangular. Originally there may have been four lintels.

The floor of the chute was sloping gently down from back to front by just under 20 degrees, comprised six rotted timber planks, presumably pine. They were far from complete and originally there were either six or seven, each about 30mm thick or a little less. When excavated they extended *c.* 0.37m behind the chute opening into the possible site of a hopper or other structure. There was no sill at the bottom of the chute opening to the front, no paired posts at the back, nor any sign of an ore hopper in the area trialed by excavation.

Against the dressing shed back wall, at floor level inside the building, there were vestiges of a possible flanking wall similar to those found at the other two chutes. However, there were only two limestone blocks here, one well-placed at right angles to the wall, the other less convincingly part of a structure. Both rested on a grey compacted sand/gravel with small stones that appeared to be an 1880s deposit.

The fill of the chute, and those parts of the area behind investigated, comprised an orange-brown clayey-sand with many small stones, with visible 'tip' lines consistently sloping gently down from south to north. These layers are interpreted as natural scree that slumped here soon after the feature was abandoned; there was no buried turf line. A shallow hollow on the natural slope above may well mark where the material slumped from. Finds in the collapsed material in front of the chute included a miner's pick and what may have been an iron hinge.

The southern plinth (Fig. 3): Abutted to the dressing shed wall, there is a projecting stone-built plinth 1.2m north of the building's southern end. It was 0.4m high, 1.9m long and 0.6m wide but has been badly damaged, perhaps when whatever it supported was removed. It is stone-built using lime mortar, with a surviving faced northern end and rubble core elsewhere. The purpose of this plinth is not known, but it is assumed it was designed to support some sort of dressing equipment.

The northern wall (Fig. 2): Attached to the northern corner of the main back wall, were the lower courses of the northern wall of the building. This was very different in character to the back wall, being much flimsier and presumably non-load bearing, designed in part to retain the bank of scree outside the building; it only had one face, to the building interior. However, traces of mortar going up the main wall suggest it once went to the full height of the building. The remaining height was up to *c.* 0.70m and it was *c.* 0.20m wide but this varied somewhat because the stonework to the north side was not faced. A length of 3.05m of wall was exposed, but its western end was not sought because it was not affected by the conservation works.

Conservation and Rebuilding: Those parts of the dressing shed back wall that had fallen since the 1880s have now been rebuilt; original parts have been repointed. Figure 6 shows the extant parts and those rebuilt. The walls over the three chutes were all intact in 1973 (BGS photographs P222192/P222193) but two had already collapsed by 1995 when the author first

Plate 7 (top left): The lower part of the central chute after full excavation.

Plate 8 (centre left): The central ore hopper, photographed shortly after the fills had been removed, but before this material was removed from in front of the wall...

Plate 9 (bottom left): The slag-block floor, timber post and wall stubs in front of the central chute, excavated on a particularly wet day.

Plate 10 (top right): The northern chute, with timber lintel in place and boards at the floor just exposed.

Plate 11 (bottom right): The rotted planks on the sloping floor of the northern chute.

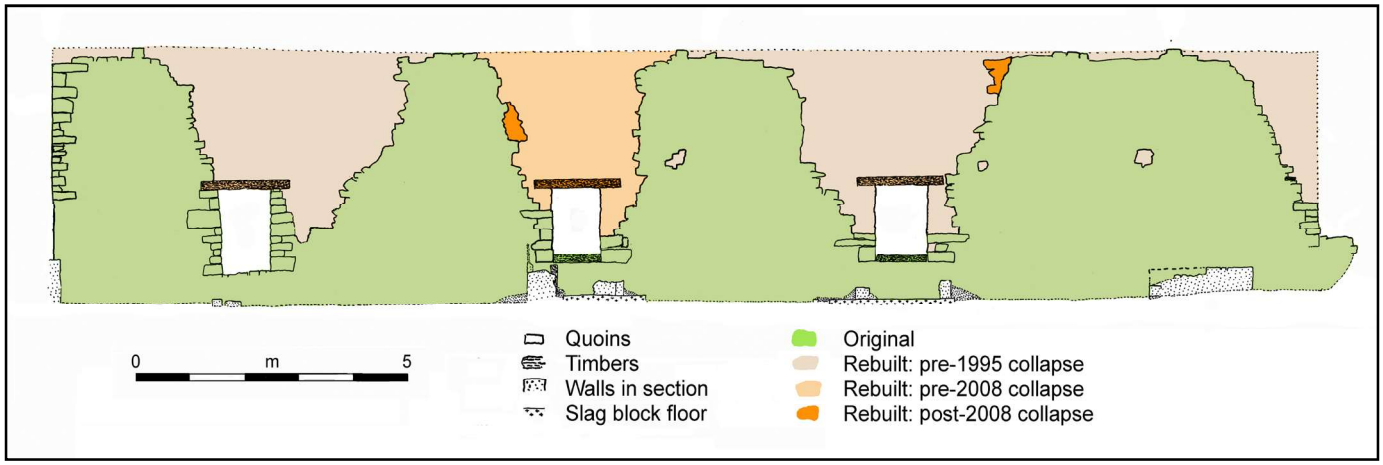


Figure 6: The back wall of the dressing shed showing the remaining original parts of the front face and those areas that were rebuilt.

inspected the wall. However, the wall over the central chute was still in place at that date but had gone by 2008 when the wall was surveyed by the author for English Heritage. Since that date only two small parts of the wall had fallen (and a third unstable part against the southern side of the central chute was taken down in 2015 to make it safe to work beneath).

The southern and central ore hoppers have now been grilled at the top to protect people and livestock from falling into them. The two original raking boards and chutes in the southern and central ore hoppers, both of which were badly rotted, were replaced with modern replicas. Similarly, the boards in the northern chute were replaced.

Plate 12: The dressing shed back wall shortly after restoration was completed, being inspected by members of a party who had just been in Deep Ecton Mine.

Interpretation

Documented 1880s dressing: We know from the documented 1880s activity recorded by the Ecton Company Limited in the Mining Journal, that they were preparing ores on the dressing floor between November 1885 and December 1888; thus the dressing equipment and buildings here were in use for only a little over three years. The documented types of equipment used to make this possible, which included ore crushers, picking tables, jigs, hotches, buddles and dolly tubs, were installed from March 1885 onwards.

After installation was complete, they processed copper and zinc ores at the same time, with these separated from each other once initial dressing had taken place. In contrast, lead ores, which are significantly heavier, were dressed separately using the same picking tables, jigs and buddles, with this equipment cleaned between each change in use. This was necessary because much of the dressing process relied on separating ores from the lighter material with which they were mixed by their different specific gravities. The various methods of separating crushed gravel, sands and fines was reliant on the crushed material being processed in water, with materials of different density settling out at different locations in the equipment. Thus, when processing for lead, much of the copper and zinc ore would be flushed away with the gangue minerals and rock (primarily calcite, barytes and limestone). In contrast, the separating equipment needed adjusting to recover the ores of copper and zinc from the gangue.

The circular buddles at Ecton would not be out of place in south-west England or in Wales, but were rare features in the Peak District, perhaps primarily used at Ecton because the dressing plant was bought second hand as a job lot from Cornwall. Only four examples are known from the region, the earliest, at the large Townend Mine (latterly Glebe Mine) at Eyam, were installed in 1863. In the 1880s came the Ecton examples, shortly after the exceptionally large mine at Millclose had them installed in the early 1880s. There is also small atypical late-19th or early 20th century example at How Grove (Barnatt 2002, pp. 37-38).

The crushing plant used water, as indicated by the 1880s statement referring to ‘an accident to the small pump which returns the water to the crushing mill’, and this may well have implications for the type of crusher employed. This stone-reduction plant is likely to have comprised a rolls crusher, for while jaws crushers were available in the 1880s, these usually crushed dry rather than wet as sand-rich slurry tended to clog this machinery.

Details of the 1880s dressing process at Ecton are hard to reconstruct; while basic principles of dressing in the late 19th century applied widely and there was a standard range of types of equipment available, the variable character of ores from mine to mine required specific equipment set up to suit local requirements. As Bowman, the manager at Ecton, himself said when they started using their equipment, ‘in treating these ores by machinery we are on entirely new ground’.

What follows is a discussion of features directly pertinent to what was excavated, including how the two ore hoppers and chutes behind the dressing shed wall may have been used, why the northern chute was different, what we now understand of how water brought for dressing was introduced to the dressing shed and how we interpret the structures within the dressing shed immediately below the chutes. This is followed by a

wider debate as to the potential stages of dressing employed at Ecton in the 1880s.

The central/southern ore hoppers: The large ore hoppers are of a type known in northern Britain as 'bouse teems' and usually found at large mines active in the 19th century. Only a few examples are found in the Peak District and these are small, occurring only singly or in small banks (Barnatt et al. 2013, sites 11, 82, 90. 99, 247. 260, 293). Ore hoppers are also found for example in Shropshire and Wales (where they were known as 'ore slides'), but they were most common in the Yorkshire Dales and Northern Pennines, where they include long banks of large hoppers at major mines.

In the Peak District there is a very small single example of mid-19th century date higher on the Ecton Hillside outside the Dutchman and Goodhope Level (Barnatt 2013, p. 46). There is a fine small single example at Nether Oxlow Mine, with others at Lees Rake and Ballington Wood Mine. The only occurrences of more than one hopper found together are a damaged bank of two at Enterprise Mine and a short bank of three at Brightside Mine, neither of which are nearly as large as those recently found at Ecton, which stand out as exceptional within the region. The Ecton examples were fed from a raised tramway at their tops, about 3m above their bases, running immediately behind the shed's back wall at roof level; this brought ore from the south where the engine house and crusher stood.

Commonly, ore hoppers are interpreted in two ways. Firstly, at large mines further north where the ore was mined by different 'companies' on bargain working at each, they were used for storage of ore as it came out of the mine. Thus, ore extracted by different 'companies' could be kept separate so that their share of the price obtained for the ore could be clearly determined. Secondly, ore hoppers were sometimes placed where ore could be stored and washed before dressing, an explanation which commonly applies in the Peak, as is obviously the case where only single examples occur.

The two impressive ore hoppers at the Ecton dressing floor built in the 1880s may have a somewhat different explanation to the two just given; for while they were for ore storage, it may be that the ore was not washed here. What we don't know is whether there are two (or possibly three) large hoppers because significant amounts of ore were anticipated (or rather hoped for) that would need to be processed. Alternatively, another possibility is that the hoppers held ores at different stages in the dressing process, with material straight from the mine held separately from ores that had already been part-processed. A third possibility that cannot be fully dismissed is that the hoppers held different ores. Whatever the detailed interpretation, the ore hoppers allowed large amounts of material to be stored so that ore-dressing was not held up once started, perhaps a particularly important requirement because once the plant was up and running they treated the metal ores differently and batch processed each for several weeks.

Another issue is quite what happened to the two ore hoppers at Ecton when they were abandoned. While the upper fills of both ore hoppers, and all the material that was seen behind the northern chute, comprises natural scree that has eroded into the hoppers from upslope after they became disused, this is not the case with the lower fills of the central and southern hoppers. These fills comprised limestone rocks that had origins ultimately as deads from within the mine, with some containing shotholes, no doubt they were already on the Salts Level dressing floor at the time they were used for backfilling the hoppers. There is no pipe deposit mineral amongst them except for the ubiquitous fissures in limestone blocks filled with calcite, as commonly found underground at Ecton. Thus, these rocks are likely to have come previously from non-productive ground, from driving a level such as Salts Level or from unproductive trials or shafts elsewhere. One possibility is that these fills purposefully introduced into the hopper for

Plate 13 (above): The southern ore hopper after its fills had been removed.

Plate 14 (below): The central ore hopper after its fills had been removed; the timber against its side proved to be displaced rather than being in-situ.

reason unknown in *c.* 1889 when the hoppers were abandoned. However, an alternative explanation seems more likely, that the material derives from the infill behind the wall between the hoppers, originally placed behind the wall here in the cut made into the hillside to build the wall, with the stones purposefully introduced to form a raised bed for the ore tramway. The rails must have crossed the two hoppers on sturdy and well secured timber beams running parallel to the wall and set in the rubble to either side of each hopper; the beams did not run at right angles to the shed wall, for there are no notches for them here, nor at the upslope side of the hoppers, which run up uninterrupted to a level higher than the tramway would have been set. Removal of these beams could easily have led to destabilisation of the rubble below them, with this allowed to fall into the hoppers as part of the demolition process. This disturbance also offers an explanation for the movement of the scree slope later, instigated by destabilisation when the initial damage was done; it is in the nature of this material that collapse would have been rapid once instigated, carrying on until steep-sided voids had been filled.

The central/southern ore chutes: The wooden structures at the bottom of both ore hoppers and running through the chute openings into the building were primarily designed to facilitate movement of ore from where it was stored in the hoppers to start the dressing process. Often, at other mines there was a simple sloping floor here, leading to a washing grate and then a picking table where the material from the ore hoppers was hand-sorted to reject non-ore bearing rocks and separate out different ores.

The chutes at the two ore hoppers at Ecton are somewhat different. The hoppers themselves are so deep that when full it would be impossible to stand in them and shovel material down the chutes; rather material in the hoppers would need raking out with long-handled rakes from inside the building via the chutes. It may also have been necessary to use bars to free material if it became locked together. The ore hopper planks in the upper half of the chute at Ecton are simply to help the 'raking out', but then the chute steps down before continuing into the room. In this lower half the chute base is plated with wrought iron sheets. Also there was raised timberwork to either side of the chute as it passed through the dressing shed wall and also two vertical posts behind that are set at the edge of the hopper. All these elements, found at both of the chutes, need comment and interpretation. At each:

- The step down can be interpreted as simply reflecting the site of a door above it, with hinges at the top rather than one of the sides, with the door set between the hopper and the dressing shed interior, designed to prevent material in the hopper spilling down except when it was needed. This would have been easier to close if the material being raked through dropped out of the way;
- Alternatively, the step down may be there because there was an iron grate here, which has now gone, placed above the 'box' in the lower part of the chute. If so, this would have had a rectangular frame and close-spaced bars and would have been where the ore was washed; ore and rock would have passed over the grate, while slurry would have been washed down into the box below. The reasons for there being a grate here, how the water was introduced, and the interpretation of the iron-sheeted chute below, are considered further below;
- The timberwork to the two sides of the two lower chutes, and the way the iron plates taper, may simply be to direct the material running down the chutes towards the chute centre rather than spilling broadly. Or, the timberwork is primarily there because it formed supports for grates;
- The now missing beams to the two sides that ran from the ore hoppers to the step down can be explained simply as part of the arrangement to narrow the flow. Or, they were part of timberwork designed to strengthen the door, by linking it to the two timber posts to the east;
- The two timber posts were fastened to the chute lintels by sturdy iron pins. This may suggest that the two posts were placed so that they braced a door in order that the weight of the ore in the hopper did not push the door and its frame towards the interior of the building;
- Alternatively, or in addition, the two posts may have been part of an otherwise-removed timber frame that helped support the tramway running over the hopper.

The northern chute: This has an opening of the same width and height as the other two chutes and there is no reason to think it was not part of the original design of the building. However, in other respects it appears to have been built very differently, with a simpler chute floor arrangement and apparently no hopper behind. Why the northern chute floor was more simply designed than the other two is not clear. Options to consider are:

- That an ore hopper here was significantly larger than the other two, and thus the trial archaeological trenching failed to reach its sides; there is no reason to think this is likely;
- That a hopper has been substantially removed. There is no apparent reason why this would have happened. That the chute itself is differently designed is a potential indicator that, whatever its purpose was, what lay behind the wall was also different from the ore hoppers and raking boards at the central and southern chutes;
- That a hopper was never built; this may be because this opening had been reserved for ore coming from Deep Ecton Mine via Salts Level; ore came behind the dressing shed from the southern end and the thus the northern hopper was the last in line and the most obvious to keep in reserve. That provision for a separate hopper was made, in part at least, presumably reflects the need to process the ore from Deep Ecton separately from Clayton Mine because royalties had to paid the different owners of the mineral rights, with the former ore coming from the Duke of Devonshire's liberty, while Clayton was within the Burgoyne liberty. By the time the company went out of business, plans to reopen this mine at depth had not yet materialised and it may be that a hopper had not yet been constructed because they were waiting for better understanding of what exactly would be required Perhaps there was also a fear that the ore would be different and need its own storage to accommodate different dressing requirements. Alternatively, it may be that output from the mines at Ecton never reached a point where they produced enough ore to require a third hopper;
- That the northern chute opening was used in a different but now unknown way which didn't require a hopper. It could be where dressing water was brought into the building. However, this seems unlikely, for no sign of a water channel was found during the trial exploration looking for a hopper. If water came through the opening, it is likely to have been in a launder to retain height above the dressing equipment in the building; if so, then the chute opening would not need a sloping planked floor.

Water for dressing: We now know that the stone-lined drain, which had brought water to the dressing floors from the 1780s onwards, no longer passed behind the dressing shed wall in a useable form; given the contour upon which it lay, it must have been truncated by the two large ore hoppers. In contrast,

we know that this feature, which comprised a water channel carved into stone blocks with roof slabs, was still extant a little further north until disturbed when 'The Folly' was built in the 1920s-30s and the education centre extension erected several decades later; examples of the stone blocks disturbed at these two times are retained at the Education Centre, some placed after the centre was enlarged, others recovered in recent years from the garden of 'The Folly'. Elsewhere along this stretch of drain, given an absence of obvious disturbance of the flat terrace at the level of its covering slabs, it is likely to still be intact at least as far southwards as a point next to 'Old Smithy Shaft' where ground levels rise a short distance north of the dressing shed (see Figure 1). The drain is certainly intact a short distance north of 'The Folly' where livestock erosion has exposed the stone blocks; here they are clear of silt and this is consistent with use of the drain in the 1880s, when it would initially have been cleaned but then used for only three years.

Thus, it seems likely that in the 1880s water ran in the 1780s stone conduit to a point well south of the entrance to Salts Level, but that it was then diverted, presumably into wooden launders before it was brought into the dressing shed above ground level for ore processing. It presumably ran in raised launders in front of the building's back wall, after entering the building through an opening in its northern end wall.

Water was also needed at the crushing shed and the water passing through the dressing shed was presumably then taken on to there. The location of a still-extant wooden launder in a stone-lined channel, set below the dressing floor level in front of the site of the crushing house, suggests that the water used here may have then been led off the floor to the workshops below for reuse at river level. Water from the dressing floor equipment mentioned above would have gone to the circular buddles and the slime pits.

The chute supports and slag-block floors: The structures immediately in front of the two chutes with extant ore hoppers have distinctive elements that need comment:

- The slag blocks used for the floors were cast locally at Ecton; they were used for the initial coal yard floor outside the 1788 Boulton and Watt engine house on the hilltop (Barnatt 2016). Broken blocks are also commonly found on the main dressing floor hillock. However, the smelters in the valley bottom below the main dressing floor stopped work in the mid-1820s and thus it must be that the blocks laid in the 1880s had either been reused from elsewhere at the mine, or that there was a stockpile of disused blocks somewhere here;
- The timber uprights, one of which survived intact, are the right height for supporting the end of the chutes, giving a good indication that this protruded *c.* 0.6m from the wall with an end that was only *c.* 0.7m above the slag-block floor;
- This low height seems awkwardly low for the chutes to have fed ore-bearing material directly onto the picking tables used for sorting the ore. Alternatively, it is exactly the right height to place a wheelbarrow beneath, thus it may be that the ore was physically transported to where it was to be washed and sorted rather than there being an automatic feed between stages of the process;
- We do not know where the washing grates were located within the Ecton dressing shed. At Frongoch Mine for example, at what was probably a typical arrangement for a large mine, the grate was in the chute with the ore raked from the adjacent ore hopper over the grate onto a picking table; at this Welsh plant the water was introduced from above in a launder that ran from inside the building into the top of the chute opening coming from the ore hopper (Palmer and Neaverson 1989, p. 319, fig. 1). At Ecton the possibility exists that the grates and associated picking tables were elsewhere in the dressing shed, with material moved to them by wheelbarrow, alternatively the grate position and design may have been similar to the arrangement at Frongoch;
- Looked at superficially there are no grates between the two ore hoppers and the interior of the building, with the chute having a solid base throughout. However, as discussed above, two explanations could apply for the step-downs that exist part-way along the chutes (see Fig. 4). Firstly they could simply reflect the position of a door between each ore hopper and its chute proper, with this allowing material to drop and thus not be in the way when reclosing the door. Secondly, it could be that the raised planks to either side of the stepped-down lower part of the chute supported an iron grate between them, and that the solid chute below was designed to take away the slurry that passed through the grate;
- If this arrangement applied, then the picking table would have been at a higher and more workable level than the bottom of the chute box; thus use of wheelbarrows would not have been necessary because the ore feed path was continuous;
- The slag-block floor could either be a hard standing for wheelbarrows or the floor of a tank that held slurry that came down the chute which would need periodic cleaning out. That there are robbed walls to the sides and possibly the front of the chute may suggest the slurry tank interpretation is correct, although no clear signs of a drain leading away were found. Also, it is unclear whether the front face of the slag-block floor ever had an adjacent raised wall; the stone work here was alternatively just the threshold for a hard standing. Using slag blocks may indicate a hard-wearing surface was required, suggesting a hard standing, while their flat tops makes an ideal shovelling surface; used either when cleaning a slurry tank or spilt material when wheelbarrows were loaded.

The Ecton dressing floor in the 1880s: There was significant variation in the types of dressing plant used at British metal mines in the later-19th century, but certain types of equipment were common (Palmer and Neaverson 1989). At Ecton the following plant is recorded, and/or has extant remains:

Engine House

- The engine house at the southern end of the dressing floor was used primarily to power the haulage of ore from Clayton Mine portal up an inclined tramway to the dressing floor. However it also powered the crushing house and presumably other dressing equipment via drive belts;

Crushing House

- Crusher, most probably comprising rolls crushers (used to break down ore to gravel sized material, with some finer material automatically produced by default);
- Classifier (used to grade the ores into different sized particles); with 'rotating screen' and thus presumably a trommel (a rotating cylindrical drum);

Dressing Shed (Grating House)

- Ore hoppers (for storage ready to feed into dressing shed).
- Grates and picking tables (for washing and hand sorting of ore). Picking was usually done on flat tables of rectangular or circular form, with a washing grate at the top end where the ore was introduced. Material of less than about 1 inch diameter was flushed away from the picking tables as their

grates typically had bars at this spacing and thus smaller material was processed in the buddles;

Outdoors

- Two large mechanised circular buddles (for extracting ore from crushed mineral sand and/or gravel);
- Hotch (hand-operated version of a single compartment jig); used at Ecton for re-processing some of the material from the buddles to further concentrate mixed material;
- Slime pits (settling tanks used to recover last fine fraction of ore in sand/clay and for reduction of pollution in the water leaving the site);
- Narrow-gauge tramways, with tubs for moving material to and from different parts of the floor. This included a short incline to first floor level of the incline engine house. At many dressing floors, gently sloping land was chosen so that ore-bearing material being processed went downhill from one stage of the process to the next. However, at Ecton the dressing floor was of necessity flat-topped and this meant that special arrangements were needed for lifting part-processed ore. They also possibly used wheelbarrows within the dressing shed and elsewhere;

Un-located

- Jigs (mechanised ore concentrators with agitated sieves, usually with belt drives for this purpose, often with several compartments used in sequence allowing them to refine concentration). A jig was certainly purchased in 1884 but where it was installed on the dressing floor is unknown; at or near the dressing shed, or in the crushing house, seem likely possibilities;
- Dolly tubs (small hand-operated ore concentrators in circular tubs); used at Ecton for processing material from the slime pits;
- Ore bins (for storage of processed ore ready for sale).

Using the 1880s dressing floor: At large dressing floors at metal mines in Britain ore processing followed a common sequence. A good example was at the large mine at Frongoch in west Wales where plant was installed in the 1860s (Palmer and Neaverson 1989, p. 319, fig. 1). At this mine storage of ore was in an 'ore slide' (ore hopper), with the first dressing stage comprising raking ore from this hopper over a grate where ore was washed, with it then raked further down onto a picking table for initial sorting to reject waste material. This was then followed by classification by size, using a trammel, of the smaller material that went through the grate at the first table. Medium-sized material from the trommel was then hand-picked on a further table. After these initial stages the ore-rich material picked off the tables at most large mines was moved to a crusher and then fed into jigs. The rejected fine material from the various treatments was buddled and sometimes then placed into slime pits, with both treatments aimed at recovery of finely crushed ores.

This arrangement may have been similar to what was employed at Ecton but there are differences and uncertainties. Pertinent points leading towards understanding the dressing sequence at Ecton are:

- That ore was brought up a long incline from the Clayton Mine portal at river level to a horizontal tramway at first floor level of the engine house, suggests that the dressing floor was designed so that ore could be taken straight round to the ore hoppers at the grating shed and/or tipped into the crusher house from above;
- Hand-picking of ore-bearing material at Ecton went beyond rejecting waste pieces with no ore but, as documented in the 1880s, also separated it into pieces that contained copper/zinc ores, and others that had lead ore, as these were processed separately;
- Material could not be hand-picked once reduced to gravel, hence it is unlikely that ore-bearing material was placed straight in the crusher as it reached the dressing floor from below, unless this was for preliminary reduction of selected material, comprising particularly large rocks that needed reduction to manageable fist-sized lumps. All material would then be re-crushed once picking had taken place and before it was placed into the jigs and buddles;
- That the shovelling boards in the ore hoppers withstood ore dropping from the tramway *c.* 3m above suggests that large rocks were not present; rather, smaller material, presumably 'fist-sized', would be more suitable as this would have done less damage to the boards below the drop point to the east side of each hopper. However, if the hoppers were not fully emptied this would also protect the boards whatever sized material was placed here. This said, the doors between the ore hoppers and lower part of their chutes must have been relatively small; thus, large stones would have led to regular choking here and this undesirable event would be avoided by controlling the size of material going into the hoppers. To what extend size was controlled by preliminary breaking within the mine before being sent up to the dressing floors is not known; presumably a proportion of material arrived here that needed further reduction in the crushing house before hand picking.

With these points in mind, a basic and perhaps over-simplistic flow model for the Ecton dressing process can be proposed:

1. Ore brought up from the mine portal to the 'first floor' level of the dressing floors, with this coming up the main incline, powered by the steam engine in the engine house;
2. Preliminary sorting of ore into 'fist-sized' pieces that could be readily sorted by hand-picking and larger material that needed preliminary crushing. This initial sorting may included breaking down the largest material with hammers before this was sent to the crushing house, to save large stones causing hang-ups in the crusher. Ore that came through the crusher that was already reduced to gravel or sand may have been kept to one side and introduced straight to the jigs at stage 7.
3. All ores (or just those of suitable size) were taken to the ore hoppers, with some or all coming from the crusher house up the short incline back to 'first floor' level;
4. Ore washed and hand-sorted at the grates/picking tables in the dressing shed;
5. Ore taken up the short incline back to 'first floor' level to feed into top of the crusher;
6. Ore crushed (or in some cases re-crushed) to reduce it to gravel-sized material, with this classified in the crusher house (with larger material re-crushed again to reduce all to material of similar size except that washed away as slurry);
7. Ore concentrated using a jig (either back in the dressing shed, or with the jig or jigs set up in the crushing house);
8. Discarded fine material from the washing grate, picking tables, crusher and jigs concentrated further in circular buddles and a hotch;
9. Discarded material from the buddles concentrated further in slime ponds and dolly tubs;
10. Processed ore stored in bins ready for sale.

It is likely that there were at least two production lines in the dressing shed, for one report in the Mining Journal mentions keeping 'one set' in production in cold winter weather, the implication being there was more than one; this consistent with the use of two hoppers. Similarly, there may have been two picking tables in each production line, for one 1880s report talks of doing 'rough grating' in poor weather, implying they also did further picking later in the dressing process. The first picking table would have been used for rejecting waste after initial washing and perhaps picking out specific ores, particularly those of lead. A second table would have been for treatment of medium-sized material after size classification of the material that passed through the grates; this may have included separation of the copper and zinc ores from each other. The 1880s accounts tell that lead ores were dressed separately from the blende/chalcopyrite, suggesting the former was picked out early in the dressing process. One report also mentions that they 'picked' poor copper ore from ore dominated by blende, suggesting this was done on the tables rather than in the jigs, and probably indicating work at a different table after the lead ores had already been separated.

There remain uncertainties:

- The Mining Journal entries give no clues as to where the jigs were located; spatially it makes sense that they were in the 'crushing house' as this would cut down the distance that part-dressed material would need to be moved. However this begs the question - if they were there, why was the building not referred to in the 1880s texts as the 'crushing and jigging house'? Also the dressing shed was a large building and thus it seems likely that more dressing processes were carried out here than just the grating and picking;
- We do not know whether the ore was washed in the chutes coming through the back wall of the dressing shed, or whether material for dressing was moved from the ore hoppers to elsewhere in this building before it was washed;
- Was the ore-bearing material to be dressed crushed more than once? The first time to produce material suitable for hand sorting, which was thus small enough to allow rejection of non-ore-bearing material and separate different ores. The second time to reduce it to gravel suitable for jigging;
- Was material lifted to 'first floor' level more than once at different stages in the process, not just to feed the crusher, but also so that it could be stored in the ore hoppers before both grating and jigging, or was material moved from the crusher by tramway straight to the jigs?
- Similarly, was picking done twice on different tables, the first time to reject non-ore-bearing material and separate different ores, particularly to pick out pieces where galena was dominant, and the second to sort smaller material and perhaps to separate chalcopyrite from blende?
- While it is documented that blende and chalcopyrite were separated on the picking tables, with smaller material was this done in the jigs by careful use of its different compartments and thus separating materials of different specific gravities?

While extensive archaeological excavations may help resolve some of the current uncertainties, this will be difficult. As is often the case, identifying specific dressing processes is not easy from surviving physical evidence, for much of the plant was timber-made and often freestanding rather than set into the ground. Additionally, excavations in the Peak, at the mines at How Grove and High Rake, have shown that dressing floors do not conform to our simplistic notions of what they should contain (Barnatt 2002; 2011). Thus, the prospects for reaching a full understanding of the Ecton dressing floors are not good. This said, the investigation reported here has been very useful in forwarding our knowledge of the Ecton 1880s dressing floor. Further work in the future, in particular targeting the interior of the dressing shed, the settling tanks and the circular buddles may well also provide more useful data.

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