WASHING FLOORS AT WINSTER PITTS, DERBYSHIRE

Lynn Willies

Abstract: Survey of buddles and related features at Pitts Mine, Winster, combined with documentary and mineralogical data suggests a mid 19th century washing floor treating low grade oxidised ores, including linnets or pyromorphite. Buddle types and features of waste heaps are discussed.

INTRODUCTION

The dressing, or washing as it was known in Derbyshire, of lead ores, and pre-mechanised dressing of minerals generally, is much less well understood than the processes involved in mining. For Derbyshire Willies (1975) has described the basic methods as they were carried out in the 19th century, and in Cornwall Jones and Willies recently (1998) described the background to, and excavation of a tin dressing floor at Cupboard Hill. In the North Pennines Killhope has been the focus of several campaigns to excavate the dressing floors there (Cranstone 1985; 1987; 1987), and earlier and current excavations at Nenthead have revealed a stamps site (probably used for crushing slags prior to dressing) and may well reveal more of the subsequent processes.

In Derbyshire a considerable amount of ore-washing seems to have taken place underground. At Winster there are substantial washing remains underground at Pitts (Penney and Dixon 1990) and Plackett (personal observation), and a mile or so away in Wensley there was a fine complex at the now-destroyed Tearsall Mine. Underground washing seems to have been a normal feature in the mines of Masson Hill in Matlock, for instance at Old Jant (Warriner Willies and Flindall 1981) and, probably, also in the Masson Showmine and Black Ox and Crichman complex. Modern underground dressing continued until about 1970 for fluorspar at Crichman and also at Mouldridge Mine (equipment from the latter can be seen at the lead mining display at the Crich Tramway Museum). Remains of underground washing equipment were still to be seen in the Devonshire (Coalpitrake) mine at Matlock Bath until destroyed by vandals, though the underground waste heaps are still apparent. What all these mines appear to have had in common is that the deposits were largely stratiform and that there may also have been natural cavities to give space for both the processing and for the waste produced. The advantages of underground are fairly obvious: water, constant climate, reduced haulage and winding and, sometimes, perhaps, concealment.

Except where there were substantial structures, such as the limestone rubble-built ore kilns at Brightside Mine below Longstone Edge (Fletcher and Willies 1975), or, mainly in other areas of Britain, the masonry supports for a waterwheel and/or crusher, remains of surface washing floors are much more subtle. Equipment such as vats and sieves had alternative use or rotted away. The main structural features are low and even before grassing and soil development over them, were easily filled in by rain erosion of the fine material on the sites. They are also extremely vulnerable to site restoration by farmers, or site destruction for the fluorspar, calcite or barite the sites contained.

With experience and in suitable conditions on undamaged sites, however, it is sometimes possible to make out features of slight depressions and trenches, which, in drought and melting snowfall develop a much clearer pattern. Often the best guide is not the structures, but either the source of the material - usually a reworked hillock, or the disposal area of the waste, ranging from low mounds, often populated by metallophytic plants (e.g. leadwort, pansy, thyme), to substantial embanked slimes ponds. Such features are common around Matlock, on Bonsall Moor (see e.g. Brossler 1998), in Winster and Elton, and at Magpie Mine at Sheldon. Further north the remains have more frequently been disturbed but substantial remains can still be found around Bradwell and Castleton, sometimes associated with the use and remains of horse crushing circles of which up to a dozen survive.

The main washing processes have a long history - the golden fleece is just one early example - and all the main features of crushing, jigging, and buddles and strakes were illustrated by Agricola (1556). Though it was fiercely disputed at the time (Kiernan 1989 p176 *et seq.*), it seems at least possible that continental ideas infused British practice. A similar migration of much the same ideas was alluded to by Pryce (1778 p243) when he stated that the Cornish "were almost entirely obliged to the Derbyshire and other (northern) lead miners for the best method of dressing copper ores in the first place". By 1778, however, it was possible for Pryce to claim Cornish pre-eminence of the "nice management" of dressing practice and it is possible a reverse migration of ideas from Cornwall was partially responsible for the local importance of buddling of low grade material around Eyam and, especially, Longstone Edge (Willies 1988 p156) where buddling, not popular with the miners, seems to have become a specialised occupation. There may well have been Cornish influence in the fairly widespread buddling which seems to have taken place in the 1850s and 1860s.

However, until mechanical tables and round buddles were developed in the mid-19th century there do not seem to have been any fundamentally new developments for several hundred years and it is possible we should look, not so much at the ability to supply buddled concentrate, but on the demand for it. There are two possible reasons for the latter. The first is that new smelting techniques evolved to deal with low grade material, for which improved blast furnaces with multiple tuyeres were certainly around by 1830 and, in the furnace known as the Spanish slag hearth, in a much improved form by 1850 (Willies 1991). The second may be particularly applicable to Derbyshire, in that it had become difficult with falling prices and exhaustion of readily got deposits to maintain the supply of good quality ore to an established smelting industry. It may be possible, in fact, to

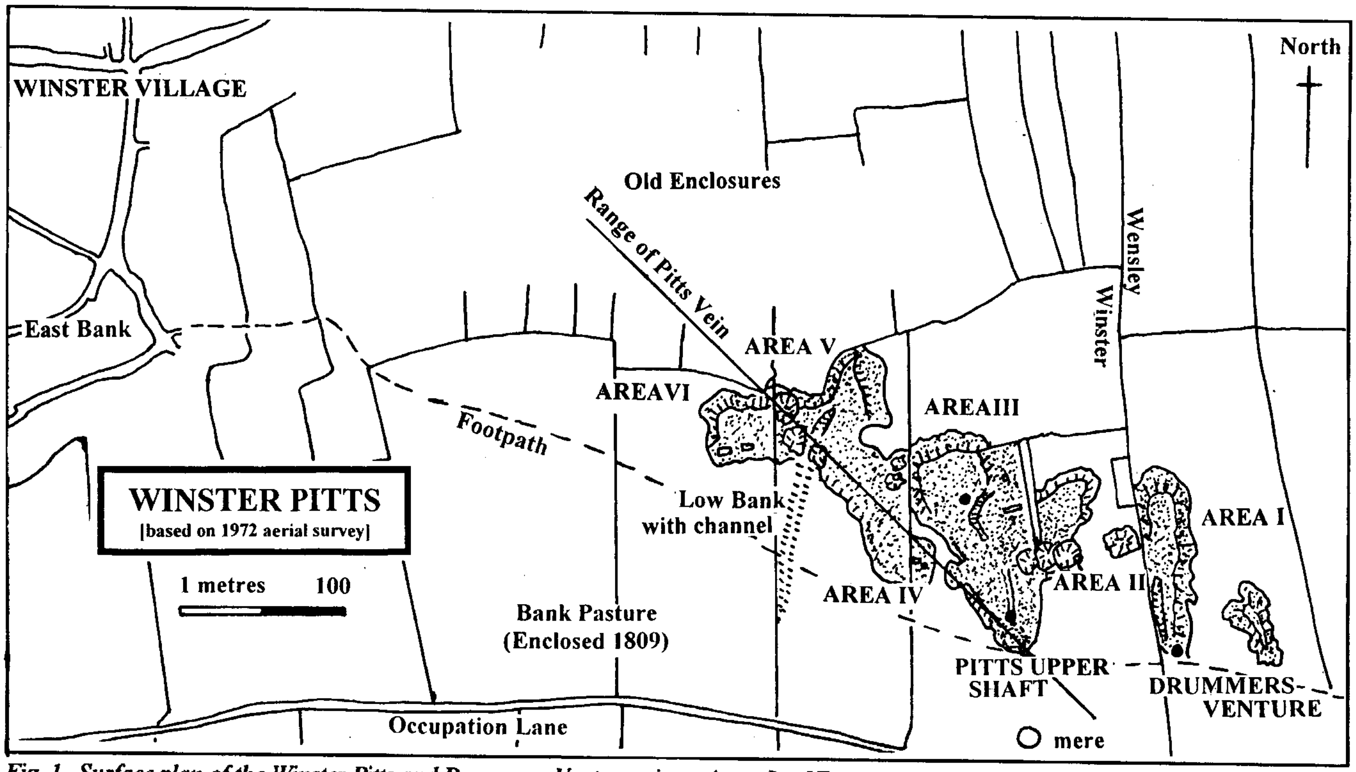


Fig. 1. Surface plan of the Winster Pitts and Drummers Venture mines, Areas I to VI.

envisage washing practices (after hand-picking) just before and after 1780 as being mainly for the purpose of eliminating moderate quantities of gangue material from mine ore. In contrast, by around 1780 it was often a matter of "working-up" a saleable, possibly still low-grade, concentrate from previous waste or from mined material which would formerly have gone to waste. In some cases this led to reworking underground, as, for instance, in the 1850s, from the waste piled in stopes at Victory and Burnt Heath mines, near Eyam (Willies 1983 p360) or of old hillocks at surface, or even, as shown below at Pitts, by opening up very low grade unworked surface deposits.

THE HISTORICAL AND GEOLOGICAL BACKGROUND OF WINSTER AND PITTS

Winster is at the southern end of the High Peak area of the Derbyshire orefield and in the late 17th and 18th centuries was amongst its most prolific producers, though mining, and the employment position of the village suffered a considerable decline after the 1780s (Willies 1986 p259).

Soughs (drainage tunnels) were the main means of the by then necessary drainage in the late 17th century at Winster. Then steam power with, later, even longer soughs, were used for drainage on a comparatively large scale between 1717 and 1785 at the three main mines of Yatestoop, Placket and Portaway. These mines were developed beneath the shales which created enormous water problems. Their richness, which justified the necessary investment, can be, to some degree, presumed to have been discovered earlier, to the south, where the exposed limestone was drained naturally or by fairly short soughs. Winster Pitts Mine is one such site, related to the swarm of veins which ran towards the Yatestoop, and its title. This, with others on Bank Pasture, was quickly taken by the London Lead Company about 1720 when they expanded into Derbyshire. At Pitts and at other veins on the Bank Pasture, this came to very little, probably since the deposits largely occurred in dolomitic limestone above the Lower Lava (an impervious basaltic horizon) which had been worked by simpler and earlier methods. Some of the underground workings there have been described by Penney and Dixon (1990). They produced evidence of underground washing or dressing of ores, some of which may be roughly contemporary with those found at surface and described below. Underground washing of ore seems have related to the cleaner and coarser portions, probably mainly related to the replacement-mineral from the dolomite. These were treated by hotching, in a counter-balanced sieve. Finer material, if it had been treated in large quantities, would probably have been carried by water into the drainage system, causing blockages and it thus seems to have been brought to surface for treatment.

In the mine the lead ore, galena, lead sulphide (PbS), was predominantly found in stratiform, pipe-type, deposits overlying a basaltic lava, with fluorite, calcite and especially barite as the gangue or waste mineral. The top of the lava has an ash deposit or tuff and this, with the uppermost part of the lava, has been altered or weathered to yield a metre or more of very soft clay above which, and possibly in which, the ore occurs. Above the lava the ore replaces the dolomitised limestone, sometimes completely, sometimes partially, so that in the latter case the limestone and ore are intimately attached to each other. The surviving dolomitised limestone has also probably been altered by mineralisation, to such an extent that it has sometimes broken down into a soft, almost powdery texture and consistency. It is very likely that galena also occurs within the altered basalt and tuff horizon, just as it frequently does in similar circumstances around Matlock (Walters and Ineson 1980). Most such deposits have also been affected by weathering and physical breakdown and local transportation by underground stream flows leading to redistribution. Taken together, in the difficult process of mining, large amounts of clay, mineral, and rock fragments ranging from powder to lumps are admixed into a *mélange* of a more or less muddy consistency which was either originally left in the mine, or, because of lack of space in the mine or a suspicion it contained enough lead ore to be worth treating, was brought to surface where large quantities went on to the hillocks with or without being washed.

SECONDARY MINERALISATION PROCESSES

During weathering, whether of material *in situ* in a vein, or in old stopes or waste hillocks, sulphide material, such as the lead sulphide, galena, is oxidised to carbonate (cerussite - known locally as white ore), some to sulphate (anglesite) and, specifically in the Winster area, to a chloro-phosphate (pyromorphite), known locally as green linnet ore from its characteristic green colour. The cause of the latter has not been fully determined, but may be because of the local presence of phosphatic material originally derived from an enhanced horizon in the (previously) overlying shales (Ford, pers. comm.) and it is possible this phenomenon is more widespread. These oxidation processes take place naturally in the weathered material found as soil above vein outcrops. Breakage of galena in the mine, increasing the exposed surface area to air and meteoric water would have the effect of hastening the oxidation of primary sulphide to secondary minerals, whilst the even higher degree of comminution during the washing or dressing either underground or at surface would accelerate the process still further. By the mid 19th century when a major reprocessing of such material took place, some of it had probably been exposed to these artificial secondary oxidation processes for at least two centuries.

It is clear from an agreement of 14th of June 1803, that green (linnet) ore was reasonably abundant at Winster Pitts. Samuel Heathcote of Winster then made an agreement with Thomas Saxelby and Co, a Bonsall lead smelter, to buy all such ore he could get at £3-3-0 a ton when lead was £25 a fodder at Hull, rising and falling with the Hull price (Flindall 1998 p258). Whether this was weathered surface material or was to have been gained by underground mining is not stated. In recent years Dr. N.J.D. Butcher has found good amounts (of mineralogical interest rather than mining quantities) of pyromorphite, or "green ore", at Brownedge, also in Winster.

Cotter-Howells (1991 p153-5 and *passim*) found that soil samples in Winster, including in the area presently being examined, had up to >50% pyromorphite, and >10% cerussite, whilst the subordinate galena would also include anglesite which reports as the sulphide in the analytical technique. At Drummers Venture (which name she used for the general area rather than the specific mine), the soil lead (i.e the small percentage of lead in the soil) was around 90% in the form of pyromorphite (samples DVT 921 and 922). These levels of oxidised ore, and especially in the form of pyromorphite, may, or may not be unusual outside the Winster/Elton area.

LEAD ORE WASHING OR DRESSING

General descriptions of the washing or dressing processes show that on being brought to surface, the muddy and sludgy material was immediately washed with water, removing a clay fraction with very fine particulate lead-rich material, and leaving coarser material. Coarser material was either hand-picked, resulting in selection of lumps of "bing-ore", and rejection of obvious waste rock, whilst that left was further broken and the coarser fraction washed by sieving, in a fine wire sieve, again resulting in an ore concentrate (peasy ore), and a further retreatable fraction which was again broken. These processes were often carried out several times, but in the end, there was a quantity of fine material, which, like the muddy waste of the first process, could only be treated by buddling.

In buddling, there seem to have been two or perhaps three major forms of buddles. The first was a standing buddle, in reality simply a low tank of standing water; the second was known as a running or inclined buddle in which the sand or finer sized material was treated as a thin slurry poured down the buddle, a wood or stone-built slightly inclined trough, in which the heavier, ie. ore, grades separated out first at the head of the buddle. The trunk buddle was, in an over-simplified sense, similar to the running or inclined buddle, but was of much greater length, often serving to transport fine material to the areas for further treatment, depositing some heavier particles *en route*.

Until the mid and late 18th century only a small portion of the fine material was recovered, known as offal ore, probably since it was frequently recovered from the *waste* or *offal* of the initial treatments which had formerly (notably before the 1720s) been thrown out on to the hillocks. In the mid-18th century it became common to treat a finer fraction of ore still, known as belland or slime ore (which illustrates its size - virtually dust when dry). Even so, the waste heaps, especially where the material was very clayey, still often contained substantial quantities of very finely-divided ore, possibly two or three percent and even higher, since these levels, and higher have often been recovered by modern hillock machine-working for treatment by flotation methods. It was extremely difficult to separate fine ore from the sludgy matrix (perhaps especially where it contained much barite) to a concentrate acceptable to the lead smelters and their ore-buyers (see Willies 1991 for a fuller description of these processes, and for the related smelting processes).

This was the situation in Winster and the orefield around 1850 onwards, when the Spanish Slag hearth was introduced at several smelting sites. It was a higher temperature furnace in which it was found very low grade material could be mixed with slags from previous smeltings and profitably treated. As a result waste tips in much of the mining area was reworked, sometimes with the product being sold at a few pence per ton, compared with several pounds a ton for good quality ore-concentrate.

At Winster the Barmaster's ore accounts (Derbyshire County Library, Matlock) refer at various times from around 1800 onwards to white ore and linnet ore, which clearly relate to cerussite (and possibly anglesite too) and pyromorphite which can both be recovered in small quantities in the mines in a relatively pure state, but in the mid-19th century, a new form, "brown linnets" assumed considerable importance for a decade or so. It is now fairly certain from the sampling done by Cotter-Howells in Winster, and the evidence of smelting, and the occurrence in the account books, that this was the type of material treated at the surface at Winster Pitts.

THE SURVEY OF THE SITE

The washing (ore-dressing) floors are about half a kilometre south-east of Winster village (centred on SK 247603), on a north-sloping hillside called Bank Pasture, occupying several enclosures which were not divided until 1809 (DRO. Enclosure Act for Winster and Elton). The sites are situated on the slope below the footpath from Winster's East Bank to Bonsall. The area is now Scheduled as an Ancient Monument.

The relationship of the sites to each other are shown on Fig. 1. Area (I) - the Drummers Venture mine - is actually within the neighbouring mining liberty of Wensley (Fig. 2). The main areas (II and III) are at the Winster Upper Pitts. Area IV is a very small site independent of all other workings at the west side of the Upper Pitts close (see Fig. 3 for II-III-IV). The area V is a very substantial site with deep pits and large slime dams in the adjacent

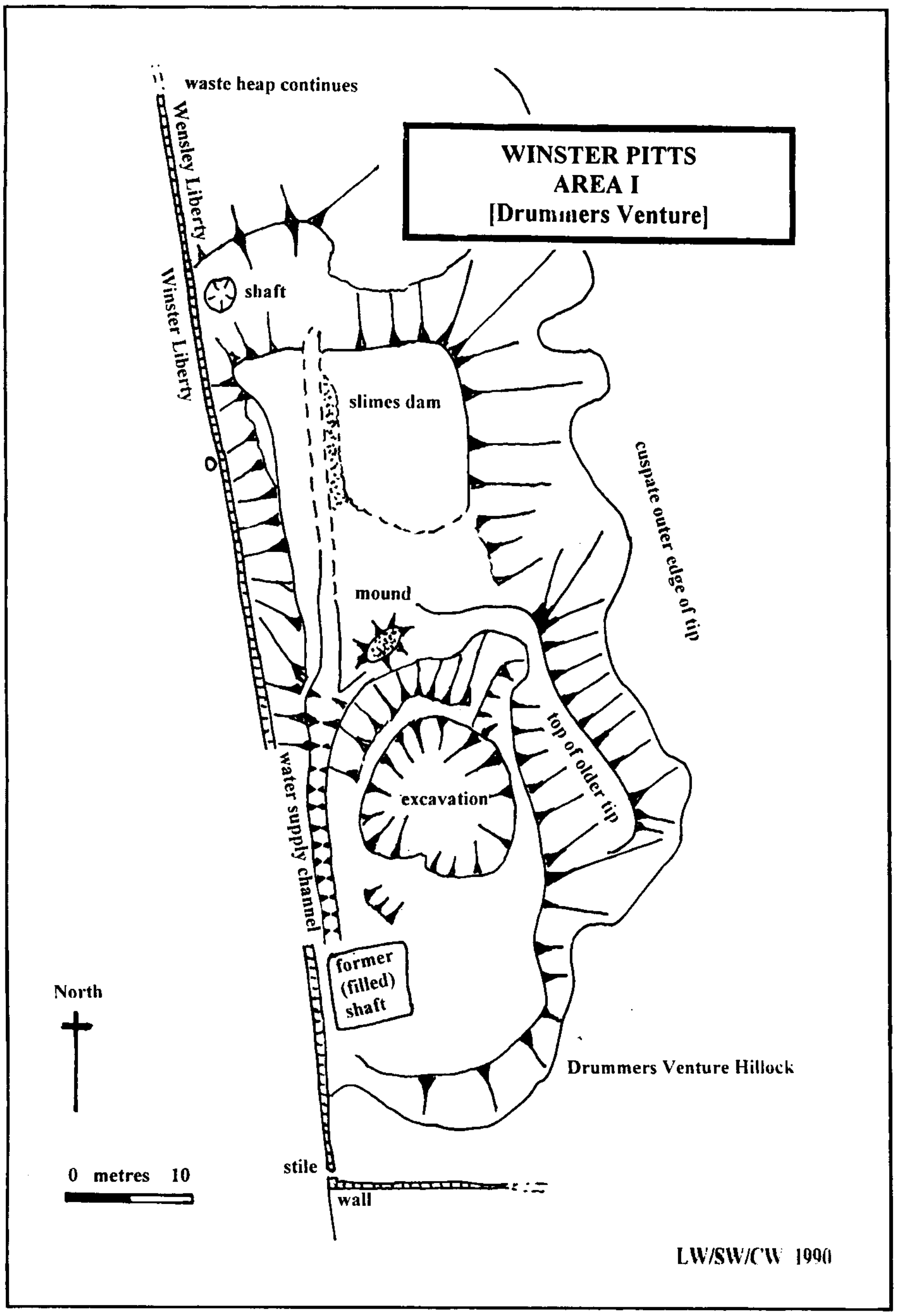


Fig. 2. Area I - Drummers Venture.

Because many of the features are not dramatic, the site was best viewed after grazing by sheep, and some features, such as the full outline of the gin circle and some channels, were only visible during prolonged drought. The areas shown stippled - nearly all very low mounds - were especially susceptible to drought, and were probably partially affected by lead poisoning. These all appeared to be of material dredged out of buddle systems whilst wet, and probably slumped into their low-mound form. Although *Minuartia verna* - the vernal sandwort, a metallophytic plant known locally as leadwort, is present, it is far less common than on many other sites, where tests have shown lead levels of 2-3%. Its general absence suggests levels of less than around 1% lead are present on most of the site.

close on the west side, which has a slight embankment running up the field to a former water supply, and (VI) is a large slimes dam in the next field west which has several buddles (see Fig. 4 for (V-VI).

Survey was carried out from a base line carried down the length of the slope, with distances to and between stations corrected for true length by calculation. Offset lines at five or ten metre intervals from this base line, depending on detail, were nearly all set out at right angles, kept as close to horizontal as possible. The few others were set out using a vernier dial. Details were plotted from these by hand-held tapes at right angles at half metre intervals or as necessary, reading to 5 cm. The general slope is around 10-15° downhill to the north. Since the survey started, as part of agricultural improvement, some field walls and a coe have been removed, a track has been driven between sites III and V, one set of buddles has been destroyed, and some deep hollows or pits have been filled-in, so some evidence was lost prior to survey, and some has been subsequently.

AREA I: DRUMMERS VENTURE MINE (Fig. 2).

This is a small mine in the close east of the main sites, just within the adjacent Wensley Liberty, and close by the footpath stile. It is noticeable, in conformity with the mining customs, that its waste heaps do not spill over into Winster Liberty. The shaft of the mine, from which the layout indicates water was drawn, collapsed some years ago, and is now filled. From its location a deep groove or water supply channel leads down the hillock to what was presumably the active washing area. There is no indication that the channel was used as a trunk buddle, but this is not ruled out. There is no evidence of the form of the buddles, but a low mound probably relates to material derived from them. Beyond this a channel appears to have delivered waste water and slimes to the slimes dam (see below for detail of construction of such dams).

The most distinctive details of this site are in the evidence of reworking of the hillock. The edges of the hillock are cuspate, created by small-scale digging into what was presumably re-treatable material. Another hillock in the same enclosure (see Fig. 1) has similar indentations from reworking. An excavation on the top of the Drummers Venture hillock, probably so placed as to be in working dirt (ie. mineral) rather than shaft sinking debris was probably also for the washing process indicated by the gully and channels etc. Useless material from the excavation has been dumped on top of older tip material.

AREA II: EAST SIDE OF WINSTER UPPER PITTS. (Fig. 3).

Except perhaps for its water supply, this appears to be completely separate from Area III, perhaps because it is (or was) in the adjacent close. The east limit of survey was originally chosen

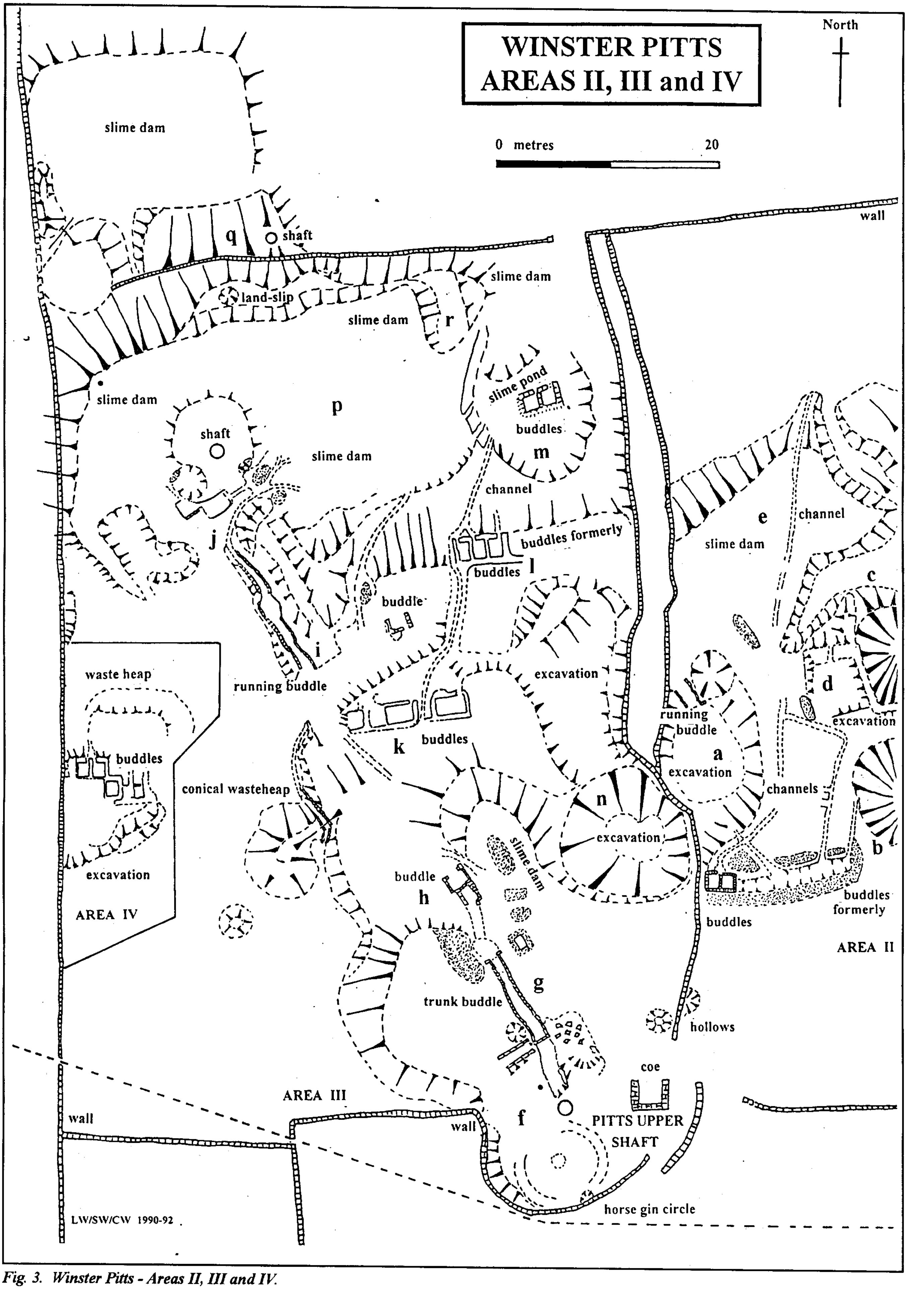


Fig. 3. Winster Pitts - Areas II, III and IV.

prior to the appreciation that the substantial hollows in the field near the buddle sites were excavations (rather than collapsed shaft hollows), but it is now apparent that the pits (a, b, c) were sources of material for buddling, with pit (b) having an inclined spiral barrow-way to within a metre and half from the bottom. Unfortunately this is now wholly obscured by dumped material from demolished walls and nearby buddles. Material could be thrown up to the barrow from the bottom at this depth. A shaft is found in the south-east bank of the pit (not on plan), so at least some material worked may have been mine-waste. Two other substantial pits are found further east in the same close at about the same level.

Only two complete buddles were found here and these have since been entirely destroyed. But adjacent were long, low mounds or banks of material which dry out rapidly in favourable summer weather, causing the vegetation to go brown and define the area. This, and the drainage channels, show there were probably six or even seven buddles in the row. A further (running) buddle is found at the edge of excavation (a). It is inclined, slightly tapered, and feeds into the excavated hollow. Except for the running buddle, the row of buddles all drained past the excavations at (b) and (c), suggesting they were in contemporaneous use, whilst the running buddle may have belonged to a (slightly) later, and certainly post-excavation stage. Some slime was run into a small pond near (d), but most ran to a larger dam at (e): the built-up height of the dumps is such as to make the whole area from (a) to (e) only slightly inclined to the north, despite the steeper underlying slope. Water at some time flowed off the end of the dam (e), but it is likely that this post-dates the time of working - it would, during working have posed very considerable problems of lead poisoning of stock if allowed to run down the grazed slopes, and more likely it drained down slowly through the dumped material into the ground below. Or, perhaps more likely, the water was recovered for further use.

AREA III: WINSTER PITTS MINE (Fig. 3).

This is the major area. The obvious top of the site has a waste hillock (f), until recently walled at the uphill side (south) around the back of a horse-gin circle and adjacent engine shaft. At the east side of this are the ruins of a small shelter or coe. Below the gin shaft a long shallow, slightly curved, trench runs down the hillside (g-h-i-j), which seems to have acted both as a trunk buddle, and as a conduit to pass water down to several sets of quite separate buddles and associated settlement ponds (k-l-m). (The term slimes ponds is used for where slimes have been deposited, usually, in small hollows, whilst slimes dams are normally larger, and built up and raised successively behind a low berm, so the front face is relatively high and steep above the general slope of the hillside. (n) is a large hollow or pit from which material has been excavated and barrowed to the buddles at (k). Material also seems to have excavated near buddles (l) (see Plate 1) and (m), leaving the double walled, linear plantation dividing sites (II) and (III) raised between one and two metres above the general field level.

The trunk buddle eventually ends in a large flat-topped mound (p) with a slightly raised (10-20 cm.) berm at the downslope edges. This may overlap a lower slimes dam (q), though the true relationship is difficult to see because of a small landslip. Another, smaller, dam seeems to have started after, and at the side of (p) at (r), and may mark the last slimes produced on the site.

The shaft clearly acted as the main source of the water required, though the actual source is not apparent today underground because of debris at the bottom of the shaft. A mere or pond, probably mainly for livestock, is to be found about fifty metres higher up the hillside (see Fig. 3) and might have formed a supplementary source. Since the depth of the shaft is around 77 metres, it seems likely a horse gin was used for lifting the water required.

Along the route of the trunk buddle, the top section is inclined fairly steeply (g) and is lined with rubble limestone, which ends in a step and basin. A mound of waste material, probably dredged from the basin, has been piled at the west side, and other material may have been run into a small slimes pond on the east side, possibly with some of it raked into low mounds, shown stippled. A short distance further on, beyond the stone lining, is another stone buddle (h), nearly horizontal with a small step. Waste material from this may have been, literally, run down-hill and then steeply uphill on a barrow to be dumped on top of the conical wasteheap (plate 3), and other material may have flowed, as a slurry into a slimes pond just below the buddles at (k). A drain, purpose unclear, runs under the low connecting spur to the conical wasteheap.

Lower still on the same slightly curved line of the trunk, is another, slightly tapering, inclined running buddle (i) at the head of another stone-lined section. The sections of the trunk here have either heaps or long mounds of waste alongside, clearly derived from the buddles. This is probably somewhat coarser material retained in the trough and, in the lower section at (j) a small excavation by a rabbit revealed a fine, clean white material, probably calcitic sand. The slimes dams on the other hand, in the places where the material is revealed, have definitely clayey material in them. Most other mounds are either low, or are flat topped and are reached from the uphill side or along the contour.

The slime dams, notably (p) have clearly been raised in small stages, as the successive dams behind the berm filled with slime. The berms were probably created by simply raking solid material (i.e. settled sludge) to the sides. The slimes dam (p) partially overlaps a gate-post and section of wall on the west side of the close and thus post-dates the 1809 enclosure. This is the only firm dating evidence so far found on the site, though it is clear that buddling operations were the last substantial phase of mineral operation to have taken place there. The general confining of the sites by the walls also tends to confirm a post-enclosure date for the work. The dam also entirely obscures the earlier shaft mound of the shaft at just-off-centre, and it may be that the dam reaching the height of the shaft collar may have caused the termination of slimes dumping there - resulting in dam (r) being started.

It is not clear how much material came from the Upper Pitts hillock, but just below the east side of the hillock is a large excavated hollow or pit (n). This was at first considered to be a subsidence on a shaft, but it soon became clear that it has been excavated and taken by barrow-way to the set of buddles on the downhill side (k). The excavated area here and lower down the slope may have been washed downslope from the Pitts Vein (see Fig. 1) following erosion or it might be dumped material from a much earlier phase of underground working.

The buddles at (k-l-m) are all roughly similar, though sizes vary slightly. They are formed of stones, nearly horizontal, with an opening in the lower side which communicates with a small trench to convey waste water and slime to the ponds. Typically they are about a metre wide and nearly half-as-much again in the other dimension, and 20-30 cm. deep. Detail is obscured by a thick grass sod, but it can be presumed the stones were set in clay,

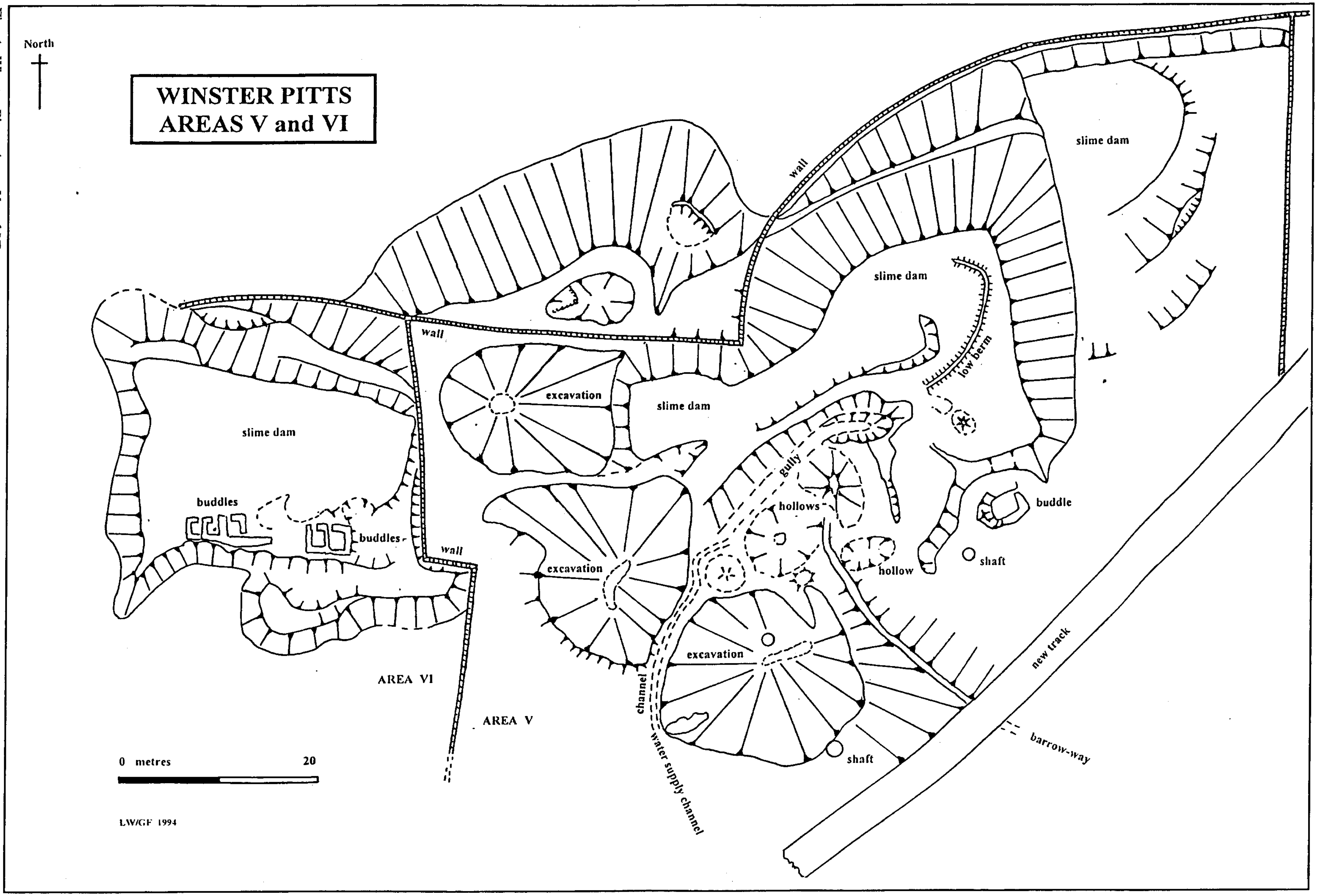


Fig. 4. Winster Pitts - Areas V and VI.

of which there was no shortage. The front hole would probably have been stopped with either a board or stone luted with clay. They are arranged in a row with between two and four or more. The two buddles (m) were partially buried, in what, clearly later, became a slime pond for buddles (l). The area of (l), prior to its use for buddling, was also an excavation, and it is possible that its buddles were fed from material excavated near (k).

AREA IV: SMALL SURFACE WORKING ON PITTS VEIN (Fig. 3).

The Barmaster's Plans show Pitts Vein ranging from the Upper Pitts Shaft north-west through this site (Fig. 3). Except for the visible features from the buddling activities, there are no other signs of ground disturbance here: no shaft or pit, or waste hillock. This site was initially important in our concept of the processes used, since it quickly became clear that here at least the buddling was of soily material from close to surface and was entirely unrelated to mining waste from underground. From this developed the concept that the hollows or pits found on all the sites were mostly excavations, not subsidences as generally suppposed, and that some material produced was primary excavation rather than secondary (hillock) working.

The site has a small area of shallow excavation, hardly more than the soil and probably to less than a metre depth. The buddles themselves, and a low arcuate dump-mound or developing slime pond are formed on the downslope side. Nearby was a small building or coe, partly set in the wall, hardly more than a metre across internally. The wall and building were removed during the survey as part of agricultural development.

AREA V (see Fig. 4).

This consists of very large slime-dam (Plate 2) and some smaller, at the bottom of the adjacent close to that considered above. Some material was worked from the rough, pitted and hollowed ground adjacent to the Winster Pitts close, on the slope above Area V (see Fig. 1), which has now partially been agriculturally smoothed, and has not been surveyed. The rough, pitted area was linked to the washing area by a track and raised "causeway", probably for barrows. A very substantial quantity of ore also appears to have come from three large, and several small hollows within the area. The hollows are above workings on a vein explored underground from the nearby Horsebuttocks Mine (Penney and Dixon 1990), which may also be the Pitts Vein. There are several shafts on the site, which appear to have had mine waste removed from around them.

The main slimes dam has a gully formed by a wall and bank running into it, though its function, except for some form of access is not clear, and although a solitary buddle was located, it is at a lower level than the main slimes dam. There is no obvious location for the buddles which it seems certain were used here.

The most unusual feature of the site is the water supply, which appears to have flowed down a either a clay or wood lined channel along a narrow and low embankment running about 150 metres up the field, into a tree'd hollow (see Fig. 1 and Plate 4). No water is visible there today. At the bottom end a pipe or bridged launder, just above the southern limit of the plan of the area would have been necessary to bring the flow into the working area.

AREA VI (Fig. 4).

This is a short distance south of Horsebuttocks Mine, and may originally have been part of its surface workings. The substantial slimes dam is covered with long grass which obscures details except for the row, or two rows, of standing buddles (Plate 5). There is no obvious source for the material treated which suggests it was transported in from hillocks some distance away.

INTERPRETATION OF THE SITES

The features seen on these six areas are all commonly found in the southern area of the orefield, but no other surviving site seems to have been so intensively worked in this particular way. As noted earlier, similar large slimes dams are found west of nearby Elton for example, and there are numerous examples of small buddles and slimes ponds above Matlock and on Bonsall Moor. They seem rarer further north in the orefield, but the more likely locations have often been heavily opencasted in recent decades. It may be the intensive working of pipe-type deposits, or indeed their own origin, resulted in suitable material for this type of processing, implying that the mineralised dolomite/basalt circumstances are the governing factor, or it may be that the localised presence of phosphorus has locked up substantial quantities of oxidised lead in the soil and near surface that otherwise, in other oxidised forms, may have been leached away.

There are three types of buddles on the sites:

1. The long trunk buddle. From its position extending from the shaft, the long trunk buddle at Pitts may have been used to treat material raised direct from the mine. It is inclined and this is generally indicative of normal washing-out of the clayey matrix as a first stage, coupled with some recovery of better quality pieces of ore. It is also clearly the means water was conveyed about the site. The shorter trunk buddle at Drummers Venture may also have been used to treat underground mined material, but could also have simply been a trough to convey water from the shaft, as, unlike the former, it has no obvious steps or widenings.

2. Inclined or running buddles, of which there were only two on the Pitts area, were usually used for treating a slurry of finely crushed material, whether from the mine or recovered from hillocks, but were probably not suitable for treating the very fine slimes or clayer material.

3. Standing buddles. The majority of buddles found were the standing type - simply a trough of water with a removable board to run-off slime to the settling ponds or dams after treatment. The first probable use was for removing clay from larger fragments of mineral simply by stirring the material in water and lifting out the larger fraction on a shovel for handpicking or sieving etc. The second would be to extract very fine material from the mud left after the first. This can be effectively done by a form of panning or vanning, using a shovel in a way analogous to panning gold or vanning tin. Only a crude concentration was required, as a concentrate with a relatively small percentage of ore in it would be acceptable in the Spanish slag hearth - a concentrate heavily contaminated with sludge would admirably fit the term "brown linnets" which was the probable product from the sites.

Although use of buddles long preceeded 1800, the date of working, based on the partially buried gatepost and conformity of the areas with separate closes was post 1809. It was the final mining work done on the site, which suggests a mid or late 19th century date, and the type of material treated suggests feedstock for the Spanish slag hearth, which would place the work after c.1850, and probably prior to 1870.

Although working of mineral from surface has clearly often been done along rakes and pipe-deposit outcrops, this is the first site where it has been able to confirm the extensive working of oxidised lead ore from a secondary enrichment zone.

The survey also highlighted for the writer our lack of knowledge regarding the structure of waste heaps or hillocks. It is possible to theorise about these. For instance, an ideal model might have a central concentric ring around the shaft of the material excavated from the shaft itself. Assuming the desire for minimal labour, using a flexible means of transport like a bucket or wheelbarrow, then subsequent material, perhaps waste from the workings entered from the shaft, would also be deposited in a series of rings (or spirals?). Obviously a great many factors might disturb this ideal situation: one such at Drummers Venture was the shaft position against the boundary wall of the liberty. Another might be a decision to tip different types of waste around different parts of the heap. Tipping downhill would obviously be favoured. The use of fixed plant such as a railway would probably lead to the development of "finger tips", or tips aligned parallel along, or jutting out from, a hillside. A reworking and re-equipping or too large a distance to the tip margin might result in a decision to raise the shaft collar and the tip about it (this happened at Magpie Mine, Sheldon, for instance, at least twice) which could complicate the distributions still further.

However, given due allowance for these and other possible factors, it can be expected that particular grades, or similar types, of material will be found in concentric rings or crescentic segments about the tip centre: a result of this is probably the cuspate margins found at many reworked tips, such as those in the same field as Drummers Venture (the cog-work forms as noted in Brossler 1998, for Fool's Venture on Bonsall Leys, citing the present writer's since revised terminology). The crescentic excavations at Drummers Venture from inside the heap also reflect this kind of structure.

Pitts also illustrates particularly well another tip feature which was probably not very common before around 1850. Prior to then and very often after, slimes were generally allowed either to "sprawl" (as the low mounds of slimy and fine material at Pitts), or were allowed to drain and were piled in sub-conical heaps, or were dumped (or allowed to drain as a slurry behind an earth dam in a depression or valley (there is a good example on Bonsall Leys). At Pitts the bulk of the buddling slimes were deposited on a sloping hillside in heaps built up from the material allowed to run to the slimes dam. The raking of sludge outwards to form a low encircling bank allowed continued deposition of slimes, so that a steep sloping bank, or series of tiny terraces on the slope was built up to a considerable height. Those at Winster are built against the natural hillslope, but near circular waste heaps of this type, with waste delivered hydraulically, were once visible at the Millclose tips at Warren Carr in Wensley, and a similar, surviving, sub-circular mound has resulted from the build-up of calcium sulphate slurry at the Lea Lead Works site near Matlock. This was to become the dominant method of disposing of slimes in the large mines which developed in Britain and overseas from the mid 19th century. I would be pleased to hear of any more such heaps in the area, and to hear of suggestions of any examples earlier than those at Winster and nearby Elton..

ACKNOWLEDGEMENTS

These are due to the farmers on the sites: Mr Brown of Bonsall Moor Farm, and Mr Roper, Banktop Farm, Winster. Survey was carried out with the help of my wife Sheelagh Willies and daughter Clare on the first four areas and on V and VI by Graham Frost. I am grateful to Evelyn Dixon and David Penney and their colleagues for the opportunity to descend and record the Pitts Upper (Engine) Shaft, and to explore the workings below, and to John Wilmot and others of Op Mole for the opportunity to explore Plackett Mine. Peter Naylor and Pat Strange assisted, long ago, with an, as yet unpublished, survey of the washing floors in Tearsall Mine before it was destroyed by quarrying. The information on secondary mineralisation is partially derived from Drs Trevor Ford, Nick Butcher and Janet Cotter Howells (1991), and from my association with Dr John Maskill and Professor Iain Thornton of the Centre for Environmental Geochemistry, Royal School of Mines, Imperial College, London. The Derbyshire County Library and Record Offices made material available in their usual efficient way. For all of which many thanks. Jim Rieuwerts, Evelyn Dixon and Trevor Ford have all made suggestions which have improved the original draft.

REFERENCES

Clyde Surveys Ltd. 1972 *Derbyshire County Survey.* (Aerial Photographs on 1:12000 scale). 7145 No. 16366 refers to Winster Bank Pasture). Derbyshire County Planning Department.

Brossler, Adam 1998 A Survey of Surface Features at Fool's Venture mine, Bonsall Leys, Derbyshire. *Mining History,* 13:5, pp.65-71.

Cranstone, David 1985 *Park Level Mill, Killhope. Interim excavation report.* Durham County Council.

1985 *Park Level Mill, Killhope. Interim excavation report, 1983-4.* Durham County Council.

1987 *Park Level Mill, Killhope. 1987 Interim excavation Report.* Durham County Council.

1987 *Park Level Mill, Killhope.* 1987 Excavations 2nd Archive Report. Durham County Council.

Cotter-Howells, J. 1991 *Lead Minerals in Soils Contaminated by Mine Waste: Implications for Human Health,* PhD. Thesis, Centre for Environmental Technology and Department of Geology, Imperial College of Science, Technology and Medicine.

Cotter-Howells, J. and Giddens, R. 1990 Pyromorphite: a secondary lead mineral. *Bull. PDMHS.* 11:1, p.21.

Fletcher, G. and Willies, L. 1975 Brightside Mine. *Bul.PDMHS.* 6:1, pp.33-39.

Flindall, R. 1998 *Calendar of the Barmasters' Derbyshire Lead Mining Records belonging to the Duchy of Lancaster and kept at Chatsworth House.* PDMHS at Peak District Mining Museum, Matlock Bath. 517pp.

Jones, Anna Lawson and Willies, Lynn 1998 Research and Excavation at a Tin Stamping Site at Cupboard Hill, United Downs, Cornwall. *Mining History,* 13:5, pp.33-49.

Kiernan, David 1989 *The Derbyshire Lead Indutry in the Sixteenth Century.* Derbyshire Record Society, Chesterfield.

Penney, D. and Dixon, E.M. 1990 Horsebuttocks and Winster Pitts Mines, Winster. *Bull. PDMHS.* 11:2, pp.63-71.

Pryce, William 1778 *Mineralogia Cornubiensis.* Reprinted 1972 by Bradford Barton, Truro.

Walters, S.G. and Ineson, P.R. 1980 Mineralisation within the Igneous Rocks of the South Pennine Orefield. *Bull. PDMHS.* 7:6, pp.315-25.

Warriner, David; Willies, Lynn and Flindall, Roger 1981 Ringing Rake and Masson Soughs and the Mines on the east Side of Masson Hill, Matlock. *Bull.PDMHS.* 8:2, pp.65-102.

Willies, Lynn 1975 The Washing of Lead Ore in Derbyshire during the Nineteenth Century. *Bull.PDMHS.* 6:2, pp.53-63.

Willies, Lynn 1988 The Working of the Derbyshire Lead Mining Customs in the Eighteenth and Nineteenth Centuries. *Bull. PDMHS,* 10:3, pp.146-159.

Willies, Lynn 1983 The Barker Family and Wyatt Lead Mining Businesses: 1730-1875. Bull. PDMHS, 8:6, pp.331-367.

Willies, Lynn 1990 Derbyshire Lead Smelting in the Eighteenth and Nineteenth Centuries. *Bull. PDMHS,* 11:1, pp.1-19.

Willies, Lynn. 1991 Lead Ore Preparation and Smelting. pp.84-130 IN Joan Day and R.F. Tylecote, (editors), *The Industrial Revolution in Metals.* Institute of Metals. 318pp.

Colour Plates - see rear cover.

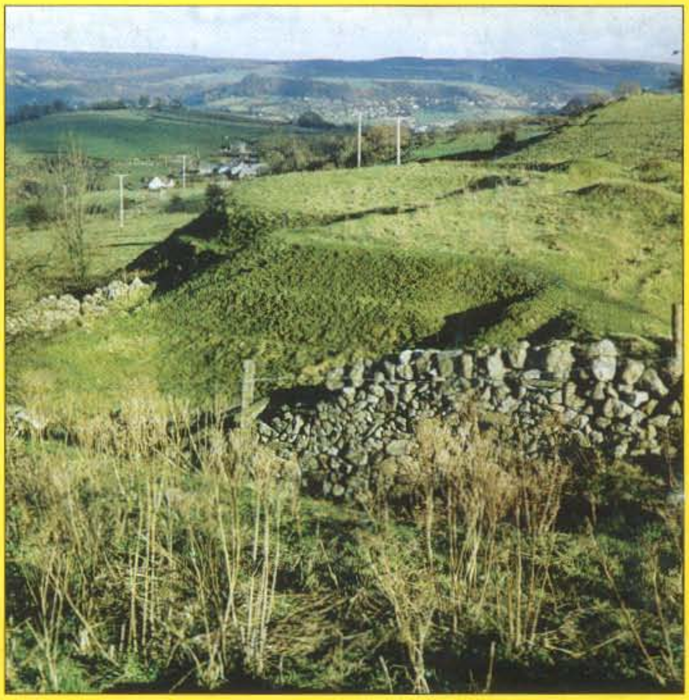
Plate 1 (top left). Area III. Standing buddles "l" looking east.

Plate 2 (top right) Area V. Flat-topped slime dams with steep front faces.

Plate 3 (centre). Area III. Conical waste-heap.

Plate 4 (bottom right). Area VI. Low hump of the water channel Standing buddles, viewed to east.

Plate 5 (bottom left). Area VI. Standing buddles, viewed to west.



Ore-washing at Winster Pitts: *(clockwise)*
1. Standing buddles in Area III;
2. Flat-topped slimes dams with steep front face in Area V;
3. Conical waste-heap in Area III;
4. Low linear hump of the water channel;
5. Standing buddles in Area VI.