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A REPORT ON EXCAVATIONS AT THE SITE OF THE EIGHTEENTH CENTURY LEAD SMELTER AT PATE'S KNOWES, WANLOCKHEAD

W.S. Harvey and G. Downs-Rose

The Pate's Knowes Smelt mill, NGR NS.866134, was on the western edge of the village of Wanlockhead, Dumfriesshire, at a height of 1150 Ft OD. Prior to excavation little could be seen of the smelter, and its existence was almost forgotten. The site is on the North bank of the Wanlock Water, a stream draining a basin bounded by the Lowther Hills which rise to 2400 Ft. Across the stream from the site is the derelict New Glengrieff Mine, the last to work; and to the west are extensive spoil heaps, tipped since the smelter was abandoned. To the north and behind the site, the ground rises to the Meadowfoot Road and a line of cottages known as Bryson Terrace. Behind these are the steep slopes of The Dod Hill.

The lead mines which created the village had a continuous history of operation from the late seventeenth century until the 1930s, and there was a brief revival in the 1950s. There were three small smelt mills working in the village by 1744, and the large smelter which replaced that at Pate's Knowes operated until 1928. It was not only the last smelt mill in the area, but was the last lead ore smelter worked in Scotland.

Fieldwork on the Pate's Knowes site began in 1973, as part of the practical work of a Summer School in Industrial Archaeology run by the authors for the Department of Extra-mural and Adult Education of the University of Glasgow. At that time the site was little more than a flattish area covered with sizeable pieces of spoil. The only visible sign of any industry were a few bolt heads protruding from the stones.

Historical Background

The mill was built in 1764, but was possibly on, or near, an earlier smelter. An entry in the Mine Journal of 1st October, 1764 records "Messrs Crauford & Co. began this summer to build a smelting mill of two hearths" (Wanlockhead Mines Journals. Hornel Library). Two more hearths and a reverberatory furnace were added some time towards the end of the century. A Bargain in the 1799 Journal refers to "refining slag in the Reverberatory Furnace" (Op cit. 9th March 1799) and another a year later directed men to dress ore "by the four Hearth Mill" (Op cit. 18th September, 1800).

The mill was demolished, at least in part, in 1843; the hearths being taken for the new and larger smelter about a mile down the valley (Letter Gibson – Stewart. 16th September, 1843). Scottish Records Office. GO.224/506). The outline of roofless buildings is shown on the 1st edition of the 6" OS, 1856, but the 25" survey of 1898 shows nothing on the site. The smelter seems to have left little record in village memories. In a taped interview with one of the authors (G. Downs-Rose. Audio Records 1972. Museum Archive), an old miner, Thomas Gass, was asked about the first smelters in the village and claimed "the smelt mills was down at Pate's Knowes, between the Mine (New Glencrieff) and the Bay (Mine). If you go there you'll find there is no growth there, its been poisoned with lead". [1] It was removed from

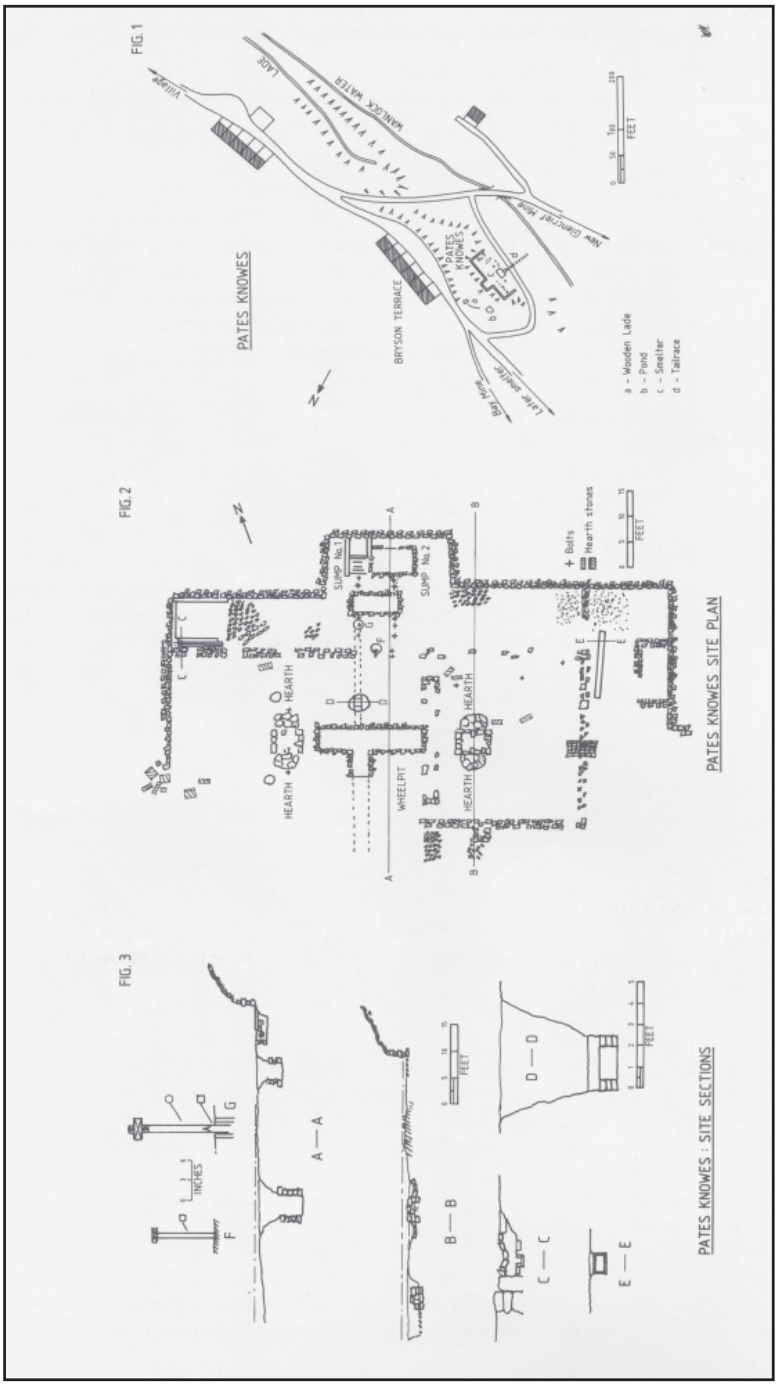
FIG. 1
PATES KNOWES
BRYSON TERRACE
PATES KNOWES
WANLOCK WATER
LABOR
New District Mine
Lower smelting mine
a - Wooden Lade
b - Pond
c - Smelter
d - Tailrace
FEET
FIG. 2
SUMP No.1
SUMP No.2
HEARTH
HEARTH
HEARTH
WHEELPIT
Bolts
Hearth stones
FEET
PATES KNOWES SITE PLAN
FIG. 3
INCHES
A — A
B — B
C — C
D — D
E — E
FEET
PATES KNOWES : SITE SECTIONS

there as the village grew. It was removed right away down to its own site". He had been told about it when he first started work in the mine (circa 1908).

The Bryson Terrace cottages were built about 1900. The ground for them being cleared by tipping the spoil down the bank above the smelter, and onto what is called 'The Wash' by the older villagers.

Excavations

The fieldwork begun in 1973 was continued in 1974 and '75, under the direction of G. Downs-Rose and Dr. P. Swinbank. Although the amount of spoil on parts of the site inhibited progress, enough of the smelter was found to promise the site could become a definitive feature of the Open Air Museum being planned by the Wanlockhead Museum Trust.

This was undertaken by the authors who were very conscious of the amount of physical effort which would be involved if the site was to be completely cleared, and the wheel pit excavated. They were also aware that excavation would have to be allied to a simultaneous programme of conservation and repair of stonework and other features if these were to be prevented from deterioration on exposure to the weather. Following advice of Mr. A. Truckel of the Dumfries Museum, an application was made for labour under the Job Creation Programme, introduced by the Government in 1975. This was successful, and those concerned with the Scheme have taken an active interest. Fifteen men were recruited.

For the purposes of this report, the site has been divided into a number of distinct areas, as below. These do not follow the chronology of the excavation, nor was their function always apparent until work was well advanced. However, the arrangement offers the best consideration of the site in terms of its original purposes.

The Preparation Area

That part of the site under the northern bank, and bounded to the south by the line of the Furnace House has been termed the Preparation Area. It is not usual to have ore prepared at the smelt mill, since costs of transport mean this is best done near the mine. But the excavations have produced clear evidence that ore washing and crushing was carried out by the smelter at some time. The area may be allied to the pond uncovered higher up, and the fact that some part at least was once called 'the Wash' is significant.

Being below a steep bank, the preparation area was the most deeply covered of the whole site. There were not only the problems of large size spoil to a depth of 4 ft, but the material on the bank would run down into the cleared areas. It was not until 1975, that part of the line of the rubble wall at the bank was found. A great deal of heavy work by the J.C.S. team was needed to uncover the whole area and grade back the loose rocks above. At the same time, what was left of the old wall was repaired and re-pointed. Its height varied from about 2 ft to 5 ft.

The spoil cover gave way to small stones and soil, and below this, at what would have been the floor level, was a compact layer made up of clay, [2] ore fines, slag

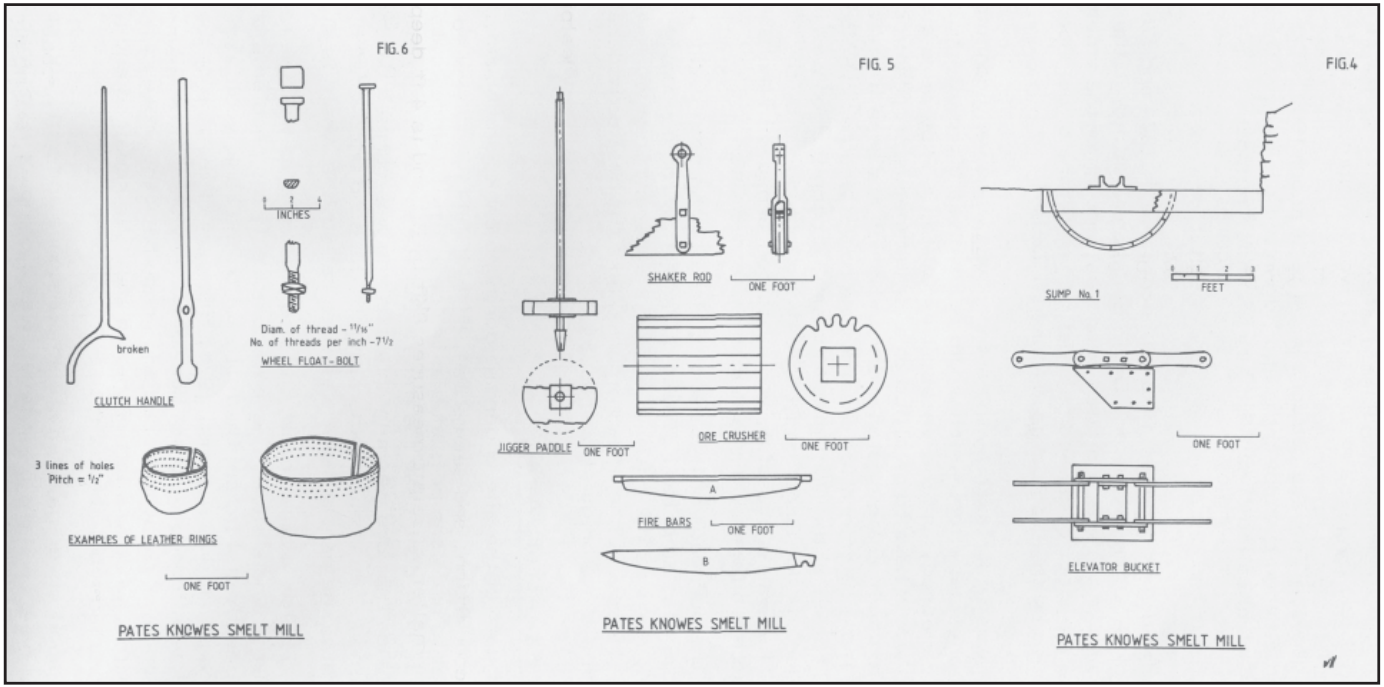
FIG. 6
broken
CLUTCH HANDLE
INCHES
Diam. of thread - 11/16"
No. of threads per inch - 7 1/2
WHEEL FLOAT - BOLT
3 lines of holes
Pitch = 1/2"
EXAMPLES OF LEATHER RINGS
ONE FOOT
PATES KNOWES SMELT MILL
FIG. 5
SHAKER ROD
ONE FOOT
JIGGER PADDLE
ONE FOOT
ORE CRUSHER
ONE FOOT
A
FIRE BARS
ONE FOOT
B
PATES KNOWES SMELT MILL
FIG. 4
SUMP No. 1
FEET
ONE FOOT
ELEVATOR BUCKET
PATES KNOWES SMELT MILL

fines, and ash. Parts had been cobbled, with rounded stones set in clay. At the western end was a rectangular area with timber beams set around it and the remains of a small wooden flume at the front. The whole was filled with finely crushed materials containing some slag. The wooden flume contained ore fines and clay.

Approximately half way along, the back wall was taken into the bank to make a bay, 25ft long by 9ft. This part of the site is undoubtedly the most interesting and thought provoking. Although it was here that a line of bolts among the stones initiated excavation in 1973, and it was not until the final work in 1976 that the full extent of the features were revealed. These included two timbered sumps and what appears to be a small wheelpit. The sumps were side by side and within the bay. That to the west (No.1) was of circular section, lined with timber staves. It is 4ft long by 3½ft wide by 2ft deep. It had once had timber baulks carrying pedestal bearings, at each side. One had been cut away, but the other remained. In the sump was a elevator bucket and links. It rested on a clear stratification of crushed rock and ore fines.

Beside this sump, but divided from it by a rubble wall, is another sump of rectangular section, No.2. It measures 9ft long by 4ft wide. It is partially floored with timber, and has a drain hole on the front side. This connects via a culvert with the adjacent wheel pit. Sump No.2 also had a deep layer of ore fines, in this case mixed with clay too in what was known as ‘slimes’. In the sump was part of a ore jigger, consisting of a wooden paddle on an iron rod. This would have been used to agitate the slimes so as to enable the heavy ore to settle.

The line of iron bolts, lying almost across the site, suggested that some of them at least were around a wheelpit lying on a N - S axis. But a trial trench in 1973 found only bedrock. That some of the bolts had been set into the rock was intriguing, but it was not until 1976 that the arrangement became clear. It was then found that there was indeed a wheelpit, but a small one and on a E - W axis. Culverts connected it to Sump No.2 and from it ran two more culverts which took the ends of some of the bolts. One of these culverts runs into the main wheelpit, the other does not appear to have any connection, and seems no more than to give access to the bolt ends. The smaller wheelpit measures 8½ft by 3ft and is 4 ft deep. It is rubble lined, the top of the lining walls having broken and fallen in. Below a fill of stones and soil was a deep layer of ore slimes which continued down the culverts. There was no sign of the timber bearers which would have been bolted along each side to carry the wheel bearings.

East of this wheelpit was another piece of cobbled floor, and beyond the area, turned towards the front of the mill.

In recent times an earthenware drain had been laid across the site from the houses in Bryson Terrace. Excavations uncovered this where it came through the bank. To have it re-laid at a greater depth was not practical, so the exposed pipe has been covered with a pier of rubble stone.

To the east were two well defined patches of coal and ash to a depth of 4" and divided by part of a stone gutter. It seems very probable that the reverberatory furnace

was situated somewhere here, but no signs of its [3] structure were found. The fact that so much of the original plant had been deliberately and completely removed to the new smelter creates particular problems of interpretation.

Towards the front is the base of a small building which is onto the eastern boundary wall. It measures about 10ft x 4½ ft inside, and the remains of its rubble walls were about 3 feet high. Evidence from other smelt mills suggests it had been a small lockfast store.

In the ground in front was found a length of wooden flume. This was of box section, 7 ins deep by 1411 wide and the top had been set in on a rebate.

The Furnace House

The main building on the site would have been the furnace house which contained the hearths and bellows. Excavations have indicated the outline of a rectangular building, measuring 82ft x 34ft. The bases of some of the outer walls remain, as can be seen from the site plan. There was little to be seen of the back wall on the eastern side, but here the bedrock is at the surface, and patches of mortar and some stones point to its whereabouts. There were no signs whatever of a front wall at the western side. There is a good depth of soil at this part, but exploratory trenches failed to find any sign of a wall. The most likely explanation is that the original frontage here consisted of arches carried on pillars of dressed stone. When the mill was dismantled in 1843, it could be then that such arches were removed, and the ground so disturbed that no certain traces remained. The wheelpit, whose excavation is described later , divides the building, and the documentary evidence already mentioned confirms the belief that those parts of the furnace house on either side of the wheel were built at different times.

Below a covering of stones and soil, the floor is of compacted clay. Pieces of slag and ore were found over the area, but nowhere in any quantity and there were no signs of the heaps of ore and peat which would have been piled near the hearths. Again, this goes with the deliberate removal of all material.

At either end of the wheelpit, and in line with it, were rectangular bases or footings of rubble stone. Each was about 6ft wide and alongside each were shallow pits, lined with stone set in hard mortar, and with the surface worn and eroded. They were filled with stones and soil, and with fragments of slag.

At first it was thought that the whole were parts of two hearths, one at each side of the wheelpit. However, once the site had been cleared, it was realised that the rubble footings were the bases of the arches which once took the chimneys above the hearths, and there were four of these in two pairs. The pits were where the slags were thrown and could have been water filled; the hot material eroding the surfaces of the stone linings. While this seems a rational explanation, no similar ash pits, so far as the authors are aware, have been found in other smelt mills.

Although there was little sign of the hearths, a great quantity of cast iron 'hearth stones' were discovered. The greatest number were in a pile at the south west corner

of the site, outside the line of the building, and they included hearth bottoms and work stones. All were greatly burned, and had probably been discarded while the smelt mill was still operational.

[4]

The base of a massive back wall was found behind the two eastern hearths, but there were no signs of any similar wall to the west. Such a wall is customary in smelt mills, and would have been essential in assisting in carrying the weight of the chimneys. But its apparent absence could mean only that, for some reason, all the stones from which it was made were taken for the building of the new mill, and this could relate to their absence.

At the site of the western hearths were two stone lined depressions which would have held the 'sumpter pots' for the smelted lead running from the work stones. There were no signs of similar depressions at the eastern hearths.

In line with the eastern arch footing, and straddling the foundation of the outer wall, was a flat pier made of assorted bricks. It measured 6ft x 3ft and had been set on a firm base of soil and stones. Nearby, but in an irregular pattern, were the end of four wooden posts.

The Wheelpit

It was known that the smelt mill had a waterwheel, and its whereabouts was the subject of search and speculation during the first seasons of fieldwork. The lines of bolts were an obvious site, and when this drew a blank, attention turned to the hollow in the ground at the southern side of the area. Trenches to a depth of about 3ft found no certain traces, but the hollow remained a likely place.

In 1976, the JCS team were put to digging a deep trial and the top of the pit was found at a depth of about 6ft. Once the outline had been uncovered, work to re-build the ruined walls was put in hand so as to give protection while the pit was excavated. When finally cleared it was seen to measure 20ft by 3ft 6ins by 9ft deep. Excavation was at first in peaty soil with stones from the original walls at depth.

Among the finds were various pieces of ironwork, furnace bars and quantities of bolts. At the bottom was part of the old wooden waterwheel. This is about 14ft long by 27ins wide and had iron straps at either end. The find was particularly exciting since the fragment probably dates from the late 18th century at least. At the time of writing it is still in place, and partially buried in the mud for its preservation. No detailed examination has thus been possible. It is planned to remove it in due course for preservation and display on the site. As with the other pits, the mud contains an amount of ore fines. Curiously, no quantity of timber such as would have come from the rest of the wheel was found in the pit, though many of the bolts found have been identified with those still in place in the wheel fragment. Near the surface, a massive piece of timber lay across the line of the pit; its outer surface had rotted away, but it was tempting to think it might have been the wooden wheel axle. However, it contains a number of knots and one would expect that only clear timber of the highest quality to have been used for an axle.

It will be seen from the site plan that the tailrace leaves the pit about half way along one si.de, and at a point where it would have been partially under one of the wheel bearings. In order to drain the cleared wheelpit of [6] ground and rain water it was necessary to open up the whole of the tailrace. This proved very heavy work, and was made more difficult by the weather breaking.

Part of the race near the wheelpit had been lined with rubble walls, and covered with timber baulks. Farther along, the walls decreased in height probably reflecting a lower ground level towards Wanlock Water than is now the case. Once open, a pipe drain was laid along the excavation and most was then back filled. The part near the wheelpit has been re-built and re-covered with timber to show its original construction.

Among finds in the tailrace were a cog wheel and a great quantity of pieces of leather. The wheel seems to be one from the ore crusher, but the origin of the leather is obscure. The size and shape of the pieces suggest they were replacement pieces for the nose hinges of the hearth bellows, but the large number found seems to make this unlikely. It then may be that they were parts of the blast pipes which once connected the bellows to the hearth tuyeres.

Although water from the wheelpit now drains into the stream, the heavy rain which fell during the excavation of the tailrace showed water draining into the ground about half way along. Although this phenomena was not explored, it seems likely that the water from the wheel had been led into a shaft and down to the mine levels on the New Glengrieff Vein to turn another waterwheel. Such an arrangement would fit into the complex system of water works once arranged to utilise every drop of surface water to the best advantage. (See "Waterwheel pumping Engines on The Straitsteps Vein", G.Downs-Rose. NCMRS Memoirs, V.2, No.2 1972).

The water draining from the smaller wheel pit, and the ore sumps, entered the main pit from a culvert in the northern wall. A trial excavation was made down to the culvert, and it was found that this had been walled with loose bricks, and covered with large fireclay slabs. One was removed for examination, and appeared to have been a part of the lining of the reverberatory furnace.

Areas Outside the Smeltmill

This report is concerned with the smelt mill site, and the whole complex of dressing floors, washing places and leats which once surrounded it has still to be explored. However, some relevant features are as follows.

Frontage – At present a rough road runs across the front of the site, and such a track is shown on the 1st ed. of the 6" OS. Excavation has shown some areas of cobblestones so it seems likely that there was once a yard in front of the mill and the track was a little farther to the south. It is hoped in time that the track can be re-routed, and the ground cleared.

Leat – The line of a leat can be seen running along the north bank of Wanlock Water towards the smelter, but there is no sign of it above the site A trial trench up the bank

found no sign of disturbed ground, and it was thought that the water might have been carried in a timber trough at this point. During the winter of 1976/77, a small JCS team were kept on with various conservation projects for the Museum Trust. While digging a drainage trench at the north west end of the bank, they found disturbed ground [6] ore fines, and part of a sluice gate. Further excavation revealed a 'D' shaped pond, measuring about 21ft x 10ft 6ins with some of the stone lining still in place. Beyond, and running almost due west into the pond, was part, of a 12" box section wooden leat.

The various maps of the site show different systems of leat as the smelter was altered, and as changes were made to the whole waterworks. Much work is then still needed to explore the whole.

The amount of spoil around the site mitigates against random exploration, and much may be deeply hidden. On the east bank part of a foundation of dressed stone can be seen under a large spoil heap. In time it is hoped that this can be uncovered, and no doubt other features will also come to light.

Discussion of Findings

The excavations indicate that the site continued as a workplace long after the smelter had closed down. This conclusion is of particular interest as it apparently contradicts with present evidence in mining records and of the 25ft OS map, and points to direction for further documentary research.

Discussions on particular points are as follows.

The layout of the foundations of the furnace house confirm the references to a later addition to the original building. The absence of some of the foundations of the western part is at first puzzling. However, in fact it bears out a reference to "…. materials from the old works could be used to complete the buildings (of the new smelter)…." (Gibson – Stewart 16th September 1843. op cit). It could then point to the western end as being the later building with the better quality stonework.

At first sight, the preparation area seems to have been distinct from the furnace house, but the brick pier which straddles the eastern wall suggests operations after the main building had been pulled down.

The main waterwheel seems to have been about 20ft in diameter. It may have been modified when the extra hearths were added, and this could be a reason for the curious way the tailrace is arranged. The finding of a crusher roller indicates that ore was crushed on the site. Ore crushing would have needed all the power of the 20ft wheel, and the finding of the handle of a dog clutch suggests that the wheel drove either the bellows or the crusher. The power from the smaller wheel was limited, and it is likely it only drove the buddles and the elevator through shafts and belting.

A significant feature of the layout of the smaller wheel is the way the culvert from it was taken through the side of the main wheelpit. Arranging such an outflow in the narrow pit was perhaps the reason why much of the large wheel was removed. The

use of the fireclay slabs to cover a part at least of the culvert also points to the work being done at a late stage.

The finding of the parts of a chain and bucket elevator on the site is also particularly strong evidence of operations in the second half of the 19th century. Although elevators have a long history, chain buckets do not seem to have been widely used until after 1850. (G.F. Zimmer. "Early History of Mechanical Handling Machinery". Newcomen Society Vol 2). Indeed the use [7] of elevators in mining and quarrying seems unrecorded until the last quarter of the century. It is then not impossible that the elevator was installed some time after the smelter had closed, in which case the plant would seem to have been in competition with the large ore plant set up near the new smelter.

Conversations with N.M.R.S. members have raised the possibility that the later plant at Pates Knowes was for some process other than lead preparation. Machinery for the concentration of barytes, fluorspar, etc. has been put up on many lead mines in the Pennines. There is no record of such ancillary work at Wanlockhead, but this is another line to explore.

An indication of some perhaps even later activity comes from the finding of the shaker type furnace bars. Although fixed bars were in use in the early 18th century, the shaker bars came much later. They were the basis for the mechanical stokers used in the present century, for by engaging the notch at one end on a cranked shaft, the bars could be moved to feed coal down the grate. That the bars found came from the 20th century steam plant at the nearby New Glencrieff Mine cannot be ruled out, but they are something of an enigma.

The above must be in the nature of a preliminary report, for much remains to be done before the history of the site becomes clear. Documentary sources need to be further explored, and the site considered in relation to the systems which served it. On a smaller scale, one of the authors' is working on a detailed examination of the bolts discovered, and it is intended to make a study of the large number of leather rings. Work on the analyses of ores and slags will also continue.

The Site as a Museum

The repair and definition of the present features is complete and the site is now part of the Wanlockhead Open Air Museum. Work on the next phase, the re-building of two of the hearths in their settings, will proceed this summer (1977). In the longer term it is intended to have the piece of the waterwheel on display with other relevant artefacts. Looking further ahead, it is hoped to have a Visitor Centre on the site at some time, and to make it the centre of the museum complex.

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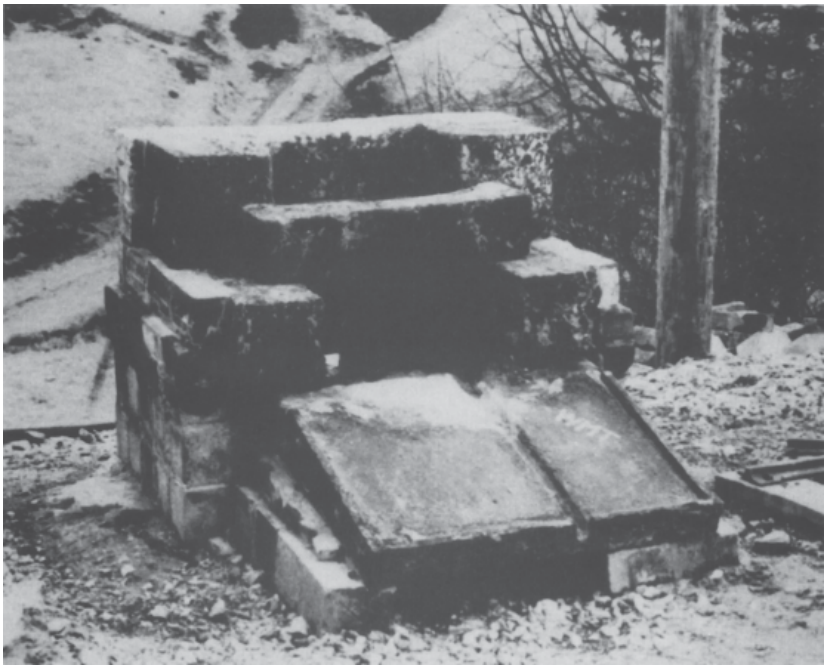

Plate 1. Trial re-build of Ore Hearth using the cast iron parts found on the site.

Plate 2. A fragment of the water-wheel partially exposed in a repaired wheelpit. Tailrace midway on the right.

PATES KNOWES EXCAVATIONS – Analyses carried out at Paisley College of Technology by Dr. D. Patterson, B.Sc. PhD. F.R.I.C.

Analysis of Lead Slags

The specimens were dissolved, and lead and sulphur were determined gravimetrically, by the methods described in W.A. Naish, J.E. Clennell and V.S. Kingswood, 'select Methods of Metallurgical Analysis'.

Other elements were determined in solution by atomic absorption spectrophotometry.

KEY to Slags

Slag No.1	Loose fine particles. Black
Slag No.2	Large (A). Small (B) lumps. Black
Slag No.3	Large lumps. Blackish.
Slag No.4	Large lumps. Grey

Slag No.1	(Concentrations, %)	
lead	41.33	40.93
copper	14.2	11.1
iron	3.4	3.3
calcium	1.84	1.71
magnesium	0.06	0.07
silver	0.01	0.01
chromium	none	
antimony	"	
silica	0.8	0.97
sulphur (total)	11.73	10.97
sulphate	1.6	2.4

Slag No.2	A		B
Lead	11.7	58.5	62.2
copper	0.03	14.35	15.43
calcium	11.0	0.44	0.18

Slag No.3	
lead	6.3
copper	2.1
calcium	17.0

Slag No.4	
lead	4.5
copper	0.1
calcium	15.2