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SURRENDER SMELT MILL FLUE.

by Sallie Bassham

SYNOPSIS

Investigations of the residual environmental impact of lead smelting at Surrender Mill, Swaledale, led to an examination of the condensing arrangements at this mill and the discovery of an unusual flue structure.

INTRODUCTION

As part of a study on the environmental impact of lead smelting, the ground near the Surrender mill chimney was investigated in 1992. The plants were typical of acid moorland and did not include any species known to be heavy-metal tolerant. The lead levels in the surrounding soil were between one and eight ppm. There was a small area near the chimney, and on the leeward side, on which nothing grew. It was about 15 metres across and it is notable that not even lichens grew on the stones. A sample from this area contained 84 ppm lead. Compared with some other smelt mill chimney sites, there is little residual environmental impact at Surrender and the flue was studied further to find out if it had any particular features which might have lessened the pollution when the mill was working.

Many factors influence the amount of pollution caused by lead smelting. The length of time the mill was used and the amounts of ore smelted may be determined from documentary sources, but the efficiency of the smelting process is difficult to ascertain many years after work finished. Mill and flue remains can be studied to try to ascertain what attempts were made to condense the fume, of volatilised lead and lead compounds, which rose from smelting and slag hearths.

SURRENDER MILL

The smelt mill near Surrender Bridge is described by Gill.[1] It is situated between Swaledale and Arkengarthdale (NGR SD991999), and has four hearths with flues which join to a horizontal flue which runs up the hillside. Currently there is a single flue about 745 metres long to a rectangular chimney, of which only the base remains. There is a ruined rectangular structure some 470 metres from the mill which is still marked "chimney" on OS maps and which was the terminus of a shorter flue according to the 1854 OS map. For the sake of brevity, and to try to avoid confusion, this structure will be referred to as the old chimney for the remainder of the article. The 1854 map marks a third "chimney" about 200 metres from the mill, but no remains of this have been found.

METHODS OF CONDENSING LEAD FUME

Early-style lead smelt mills had chimneys on the roofs, but from the late 18th century many mills were built with distant chimneys. Initially, this was to lessen the pollution effects on land near the mill and also to disperse fumes more widely by having chimneys which were taller and were on higher sites more exposed to the wind. These distant chimneys were connected to the mills by so-called horizontal flues. In fact, many traverse hill-sides at significant gradients. Most flues are surface features, constructed by digging a trench, building up side walls, roofing them with slabs of

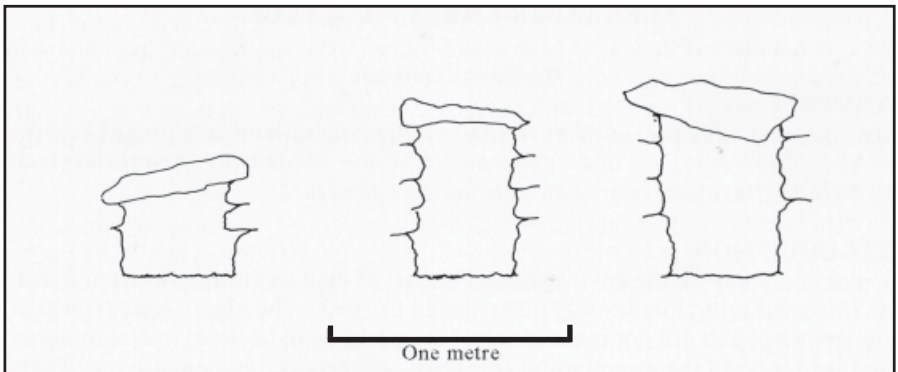

Figure 1 - Typical cross-sections of Starbotton flue, Wharfedale.

stone, or with an arch, and then covering with turf to make them air-tight. The flue at Starbotton (Fig.1 gives typical cross-sections) illustrates the early type of flue which was too small for easy access for recovery of condensed fume.

Horizontal flues had two additional functions. Firstly, they drew the fire at the hearth, in a similar way to a domestic chimney. Secondly, they acted as condensers: volatilised lead and lead compounds precipitated on the cold flue walls and could be recovered for use, or for re-smelting. It is possible that this second function was not foreseen when flues were first built. These two latter properties are antagonistic; types of condenser which were good in theory were found to be impractical because the flow of fume was impeded.

Several types of lead fume condenser are known, from archaeological remains and from documentary sources. According to Clough, Sargill and Marrick mills had condensers within the mill buildings, immediately behind a hearth.[2] Flue condensers are more common and probably the best known is the Stokoe condenser, described by Percy, pages 442-3, and Clough, page 100, and with remains, in a modified form, at Grassington, Bassham, page 39.[3,4] The fume from the mill was made to pass between several wooden baffles held in an air-tight wooden, or stone, building. Water assisted condensation and brushwood provided a large surface area for the condensate. Condensation was assisted by low temperature, a large surface area and the presence of water.

Although not compact structures, long horizontal flues make excellent condensers by meeting both the first conditions. Some have also had water flowing down the flues and into settling ponds, e.g. Grassington.

SURRENDER FLUE

The structure of the first part of the flue can only be seen where it passes under the road. There it is arched; there is no mortar and the soil over the arching is discoloured to a light grey. Elsewhere, the flue remains are covered in vegetation and it is not clear if

they have been stone-robbed, or if the flue top has collapsed and then become overgrown. The flue is not built of limestone and so the heather grows freely over it, unlike Cobscar flue, for example, which is built of high-pH limestone and so is free of heather allowing its structure to be seen more easily.

OLD CHIMNEY

At the old chimney, the flue approaches from the south-east, then curves round the south-west side of the structure and enters through an arch in the north-west wall. This circuitous method of approach to a chimney (or to a condenser) is unusual. The flue leaves through an arch in the north-east wall, curves again and continues in a north-westerly direction up the hill. Since the old chimney is a structure on the flue - there is no alternative by-pass route for the fume - it is natural to consider whether it might have been used as a condenser. This would be logical, since the stone-work of the chimney already existed. It would explain why the cross-sectional area (about 3.4 metres square) is larger than for most chimneys. Also, it would fit documentary evidence referring to a condenser.[5,6]

Neither the documentary, nor the archaeological, evidence is totally convincing, however. At Durham, the Hanby Holmes MSS record refers to "***building*** *a condenser near the old stack*" and the North Yorkshire Draycott Hall record of a letter from Sir George Denys refers to "***erecting*** *a smoke condenser*".[5,6] Neither refers to re-use or adaptation. Both references are to future events, not past achievements, and it is not certain that intention was brought to fruition.

At first sight, there are substantial remains of the old chimney, the south-east wall being about four metres tall (see Plate I). There is much rubble inside the structure, however, and it is not possible to see the floor. Firstly, there is no evidence of internal structures, unlike Allendale or Grassington (where the Stokoe-type condensers have

Plate I. Old chimney and upper section of Surrender flue (S. Bassham, 1994).

Plate II. Upper section of Surrender flue and old chimney (from above) (S. Bassham, 1992).

projecting stones on which wooden baffles might have rested). Secondly, there is no evidence of condensation on the inside of the structure, again unlike Allendale, for example, where the inside of the smaller chimney shows heavy deposition in one of the sections. At Surrender, there is one projecting stone about three metres up on the inside of the old chimney and there are two planks of wood among the stone rubble. Even if the structure was not used as a condenser, it would have had to have been made air-tight with a roof of some sort at some level (so as to force the fume to continue up the rest of the flue).

Plate III. First mined section of Surrender flue (from above) (S. Bassham, 1994).

Having cast doubt on the use of the old chimney as a condenser, the possibility of other flue condensers should be considered, but there is no clear evidence like that at Grassington. At Surrender, flue stone seems to have been re-used to build shooting butts in the flue, in the same way as at Old Gang. Such structures look recent, are clear of vegetation and not keyed in to the flue walls. At about 350 metres above the Surrender mill, however, there is a wall across the flue which is not of recent construction. It stands at least 0.7 metre high, is mortared and has a grey efflorescence on the stones. Nevertheless, its position does not match any of the documentary evidence.

SURRENDER UPPER FLUE STRUCTURE

Although there is no strong proof for flue condensers, the flue structure becomes more interesting beyond the old chimney. In the first 100 metres beyond it, there are three short sections where the arching is complete. Much of the floor is rubble-covered and the flue is about two metres high with vertical walls some 1.2 metres high and a semi-circular arched roof. Some mortar remains in the roof (See plate II which also has the old chimney in the middle distance.). The next section of the flue, about 30 metres long, has been mined, driven like a level but at a steeper gradient (see left-centre of plate I). When it comes to day again there is a short vertical rise, which is easily negotiable. (Plate III looks down this mined section, the opening at the bottom is two metres high.) The break in the flue at this point may indicate only that construction was at different times or by different builders. There are, however, large squared stones beside the flue (plate IV), aligned across it and suggesting there may have been an additional structure at some time. A condenser here could fit with the suggestion of D/HH 6/4/107 "*a condenser near the old stack* ***or at the entrance to the level above***."[5]

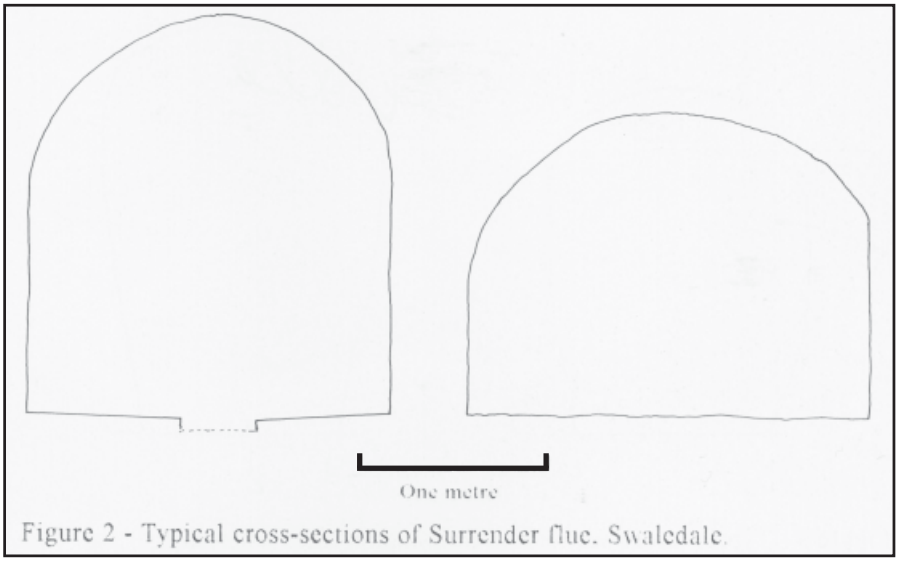

Figure 2 - Typical cross-sections of Surrender flue. Swaledale.

Plate IV Upper end of first mined section of Surrender flue (S. Bassham, 1992).

After a short surface section, the flue is mined again but, unfortunately, blocked by a fall after 27 metres. The mined sections and the flue just below them have the cross-section shown in Fig.2. The floor is roughly flagged and there is a central channel about 0.4 metre wide. It is difficult to ascertain the original depth of the channel because it is now filled with small stones. The flagged flue is not like those at Grassington, see Fig.3; where large very smooth flag stones have been laid to provide a continuous surface across the flue, and the horse-shoe shaped flue walls built on top. These stones are carefully abutted to make the whole floor surface flat. There are

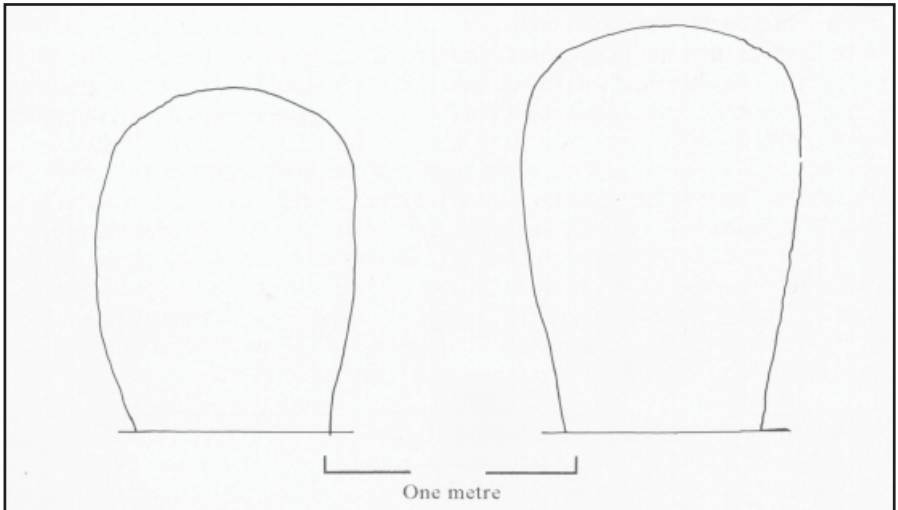

Figure 3 - Typical cross-sections of Grassington flue, Wharfedale.

access points at intervals in the flue walls and it would have been possible to shovel material from the floor. (From the settling ponds it is assumed that water was run through the flues carrying material with it for later recovery.) It would not be possible to shovel material from the uneven flue floor at Surrender, but the central channel suggests the use of water to wash the flues. There is no central channel in the uppermost part of the flue above the mined sections, however. It is not clear where and how water could have entered the flue, but it is clear where it may have come out as just above the mill on the east side there is a "doorway" in the flue and a walled area of flat ground (see plate V) which is still damp most of the year. There is a similar doorway and level settling area at Sargill mill (described by Clough as a cleaning door) and, although the settling areas are smaller than at Grassington, the flues at Grassington are longer and evidence suggests that there would have been more water in the system.[2]

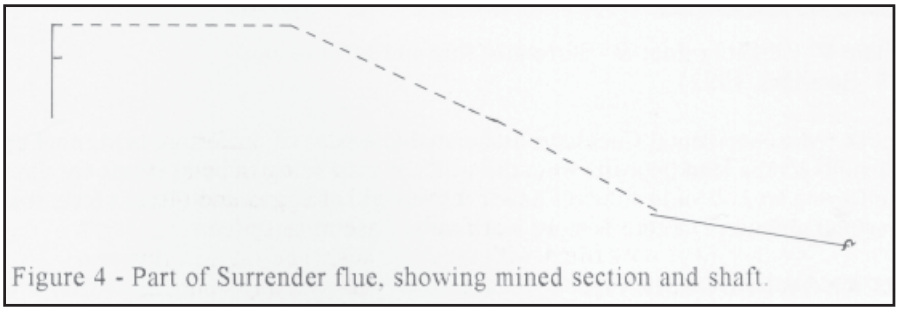

Figure 4 - Part of Surrender flue, showing mined section and shaft.

The most interesting feature of the mined section of the flue is the fact that the last section comes to day via a 12½ metres vertical shaft. It is unusual for a smelt mill flue to have an intermediate vertical section. Detailed investigation of the shaft has not been possible (and assistance would be welcomed). The top 4½ metres of the shaft is circular and stone lined, then there is a very large stone across the south side of the shaft, which may be a sill to an opening on the south-south-east side. (Is this a level?) The remaining eight metres of the shaft seems to be square cut in the rock. There is no tip at the top of the shaft, which makes me ask if it was driven from below? There is an old blocked level at the west side of the shaft top; with no water currently flowing from it. Estimates made of the slopes of the hillside between the shaft top and the start of the mined section produced the sketch of Fig.4 indicating a possible alignment of the flue. The accessible mined flue and the shaft are drawn with continuous lines and the ground surface indicated with broken lines. (Distances were measured by tape.)

The previous paragraph describes the vertical section of the flue as a shaft. Since there is no tip, it is not clear whether it was ever used for extraction, but disused shafts are marked on the map further to the north-west. Since it is part of the flue system, it would be more accurate to describe this feature as an underground chimney. It would have been a very effective condenser, using the coolness of the earth. Most horizontal flues have associated folk tales of small boys being sent up them to scrape lead deposits from the walls or men being trapped inside for days and going mad. Would attempts

Plate V Cleaning door in Surrender flue and settling area (S. Bassham, 1992).

have been made to collect deposit from a forty foot vertical chimney? There is more work to be done in this area.

ACKNOWLEDGEMENTS

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5 D/HH 6/4/107 Hanby Holmes Records, Durham Record Office "1880 - Suggested building a condenser near the old stack or at the entrance to the level above."

6 NYCRO ZLB 8/28/1 Draycott Hall MSS, North Yorkshire County Record Office "14/09/1879 Letter from Sir George Denys - I am to stop sending the smoke out of the high stack until I have carried out improvements by erecting a smoke condenser which will take me about three months."

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