BRITISH MINING No.57

MEMOIRS
1996

Meikle, T.K. 1996
"The Melting, Fyning and Stamping Mylnis at Linlithgow"
British Mining No.57, NMRS, pp.106-124.

Published by the

THE NORTHERN MINE RESEARCH SOCIETY
SHEFFIELD U.K.

ISSN 0309-2199

THE MELTING, FYNING AND STAMPING MYLNIS AT LINLITHGOW

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SYNOPSIS

The following details from the Silver Mills Accounts of 1608-09, held in the Scottish Records Office, transcribed basically from the original, condensed and summarised here in narrative form, and allied to site examination, albeit without benefit of expertise or experience in industrial archaeology, and taken together with the recently published paper on the history of the Hilderston Silver Mine, are hoped to provide an insight into early 17th century mining and recovery of silver in Scotland.[1] *It seems logical to combine site investigations with the construction of the Mills and adopted procedures following transfer of these operations to Linlithgow from the mine site at Hilderston.*

EARLIER HISTORY

The Hilderston silver vein was discovered in 1606 by a local miner prospecting for coal. The landowner, Sir Thomas Hamilton, Lord Advocate in Scotland to King James I & VI, took a lease from the King in January 1607, and mining was started under direction of Sir Bevis Bulmer who had been engaged prospecting for gold in Crawford Moor near Leadhills/Wanlockhead, under a grant of mining there from the King to Thomas Foullis, goldsmith in Edinburgh, who "*for as much as* [he] *has fund out the Ingine and moyane to caus melt and fyne the uris of mettallis ... and beiggitt housis and mylnis for this effect*" had in 1592 been appointed "*maister refiner*" under the "*Act anent the Mynes*".[2]

Within a few months Hamilton declared the mine at Cairnpapple Hill, Hilderston, to be returning a clear profit of £500 sterling per month based on the silver price of 4s 6d per ounce. Under some pressure perhaps, the Lord Advocate relinquished his lease and full possession of all structures, materials and operations to the King in return for £5000 sterling compensation. On May 11th 1608 Sir Bevis Bulmer was appointed Master of the Mines at Hilderston.

INTRODUCTION

Mining was continued by "*Pickmen*", "*draueris up of mettell*", "*drauers up of watter*", "*cuttaris of wode*", "*caryaris of wode*", "*smithis*" and "*wrichtis*", along with dressing and concentrating by "*buckaris*", "*wascheris with the seiff*", "*dressaris and wascheris with the buddill*", "*wascheris with the canvas*" and "*schoolmen*".[2] One hundred tons of the ore were barrelled and prepared for despatch by sea to England, at the King's command, for assay at the Mint in the Tower of London and elsewhere and for trials to determine the silver content and the smelting procedure which would ensure the best results.

Although the facilities already existed at the mine site at Hilderston for handling, dressing, concentrating, smelting and refining the ore, the planned scale of production apparently demanded increased facilities and therefore required transfer to another site. The site selected was near Linlithgow, 6½ km away,

(about five miles). It was agricultural land, differing substantially in ground conditions and topography, but proximity of water in the Loch Burn flowing from Linlithgow Loch, was presumably a prime consideration for the waterwheels necessary for a stamp mill and furnace bellows, even though that water was already in use at the Loch Mill 600 metres downstream from the Loch, and also at the Little Mill further downstream, shortly before the burn joined the Water of Avon.

The site also had other advantages, being close to the town (a Royal Burgh with its Royal Palace), and having ready access from the sea through Borrowstounness (Bo'ness) 4½ km to the north. Materials from England were imported through this port and then taken to Leith. Other materials came from Culross and Grangemouth (see map at Fig 1).

The viability of this move now seems doubtful in view of the high costs incurred providing the materials, labour and equipment for the works, though the King's advisers were undoubtedly prompted (or misled!), by the quality of the silver ore being extracted initially from the mines.

Following the decision, James Craig, Purveyor of the Mines was told to obtain building materials, while James Achesone, goldsmith and assayer, was appointed "*Master Meltar and Fynnar*" under direction of the Lords Commissioners of the King's Privy Counsel, and directed to secure specialist assistance and labour to develop the "*Stamping, Melting and Refyning Mylnis at Linlithgow*".

ADVANCE PREPARATIONS

Seasoned timber was unobtainable in Scotland, so James Craig sought it in England. There was none in London, but well-seasoned oak was eventually released from the king's storehouses in Berkshire and Buckinghamshire, conditional on replacement by its equivalent in green timber. He also went to Morpeth in Northumberland where much standing timber was felled at his request and hauled by road to Newbiggin and then to Blyth. Here special arrangements were made for ships to come from Newcastle to transport it to Leith and on to Bo'ness where it was stored on the shore. Craig also purchased other materials in England, including large ox-hides (18 in number) for bellows, and tarras (18 bushels), with which to '*lay*' the furnaces.

James Achesone travelled to Keswick in Cumberland for discussions with the German immigrant Hochstetter family. They were well acquainted with Saxony silver working and had been engaged for many years in the smelting of copper and other ores deriving from the mining operations in the northern counties. As a result of the discussions Achesone engaged the services of two specialist wrights, Stevin Mon (Man?), and his son, Johne, along with a 'Coillier', Cristopher Robesone, who was skilled in production of charcoal and presumably in the fire-setting of furnaces. Additionally he arranged for a Dutch mining expert, Martene Smeddell to come from Holland to Linlithgow/Hilderston. Consequent upon this visit, Emanuel Hochstetter came to Scotland, spending six weeks there,

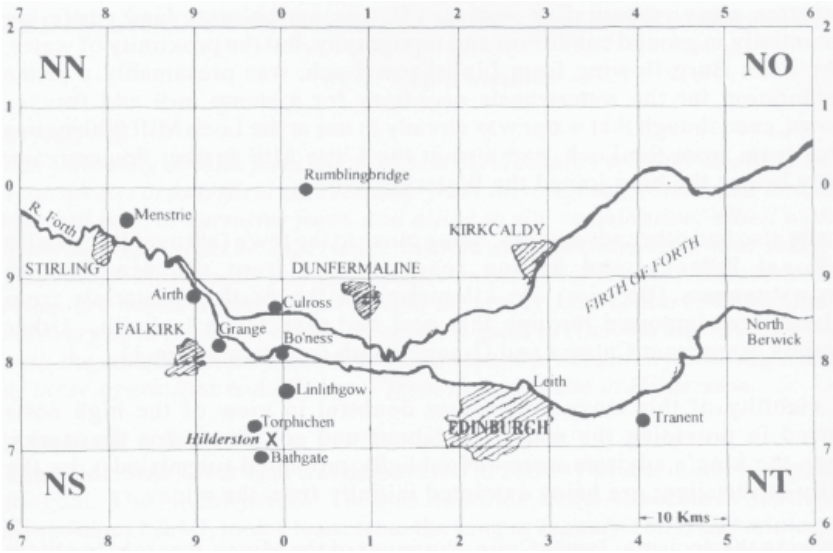

Fig.1. Location plan

undoubtedly offering guidance and advice to further the smelter works development at Linlithgow.

The Keswick wrights started work on June 26th 1608 at the old Silver Mills, built and operated by Thomas Foullis at Kingswark near Leith (the name being synonymous with the operation), where a building was converted to a workshop for advanced construction of materials destined for Linlithgow. Other locally engaged wrights and labourers joined the Mons on July 3rd at this workshop where work was continued for six weeks prior to all of them being transferred to Bo'ness and Linlithgow.

Both Craig and Achesone made further trips to London and the southern counties for specialised material, tools and ironwork for the melting furnaces which was manufactured specially at a Sussex Ironworks (see Appendix 2). The sums of money disbursed by James Craig and James Achesone up to August 14th 1608 in respect of timber, ironwork and specialist tools, equipment and materials, as well as their own expenses and those of the workmen engaged up to that date, totalled £6,687 13s 7d Scots (Note: £12 Scots = £1 sterling).

CONSTRUCTION

According to the accounts work on the '*Melting Fining and Stamping Mills*' at Linlithgow began on Monday August 14th 1608 (Week 1), and smelting started with furnace setting and charging in Week 30 (March 5th-12th 1609), although the furnaces were not finished until about April 23rd 1609, during Week 36, after a further eight weeks' work by the masons and wrights.

The wrights previously engaged on works in Leith were transferred to Bo'ness and Linlithgow. Two other wrights also started then, but in Culross, Fife, where they wrought waterwheels and axles to drive stampers and bellows.

Cristopher Robesone, with his wife as a minder, was producing charcoal in Torwood, near Torphichen, and carried out trials on peats obtained locally.

James Glen was appointed Grieve to have a watching brief over the site works generally and to record attendance on site.

During the week before site commencement, the Dutch Mining expert, Martene Smeddell, spent time in consultation with Sir William Godolphin, a Cornishman of considerable mining expertise and connections, at Menstrie near Stirling, along with Sir William Alexander of Menstrie, who, it is understood, was engaged at an early date in developing the mining of copper and lead/silver ore veins in Menstrie Glen on his estate, though little detail is known. Sir William Alexander, in partnership with Thomas Foullis, goldsmith in Edinburgh, and Paulo Pinto, from Portugal, eventually took over the Hilderston Silver Mines in 1613, following the mines' diminishing returns to the King.

The first operation on site was work on "*the wayfare for the watter from the Loch to where the Stamp Mill be buildit*", and Henry Craufurd, *Master of the Watter Warks*, with four (increasing to 12) workmen, started excavation work on a channel (the wayfare) to lead the water to the site where the Stamp Mill would be built. That site was reached by Week 4 and the channel was continued beyond this until the end of Week 8 when the site of the Melting Mill had been reached. Levelling of the ground there was carried out to allow construction of that mill to start.

The Accounts record that work on the water channel (wayfare), and the necessary mill lades at both stamp mill and melting mill sites continued for a further twenty weeks, being completed on February 26th 1609. There is no record of clay being used to ensure a watertight lining to the channel, though ordinary and refractory clays were imported from Tranent, East Lothian, and Culross, Fife, for '*setting*' of water troughs in the mills, as well as for furnace construction. The nature of the subsoil has not been investigated, but it seems the channel must have remained generally watertight though there is record of '*suitable fill*' being transferred to '*mend*' the wayfare on two occasions.

It is of note that a payment was made "*To James Hamiltoun at the west port of Lynlithgow for the loss susteint be him throu biggin of his majesteis siluer mylnis upon his lands and casting of watter gangis thairthrou*", which seems indicative there was water leakage from the lades as well as uncontrolled discharges from the various troughs, buddles, washing tables and sieve tubs.

A sluice, presumably with stoplog control, was built at the outlet from the loch into the Loch Burn, with perhaps another at a short distance downstream where

the water flow was diverted in whole or in part away from the burn into the newly constructed '*wayfare*' to provide the substantial flow necessary to drive the waterwheels and service the stamping and washing operations. The net effect of this was to create substantial interference with the operation of the two flour mills downstream, and the accounts include the following entries.

> "*To Robert Stewart, Baillie of Linlithgow, in the name of the Countess of Orknay, in parte of payment of the soume of Twa hundreth and fourty pundis for the yeirlie dewtie agreit uponn to be payit to him yeirlie for the Lochmylne besyd Linlithgow in respect the same myln is maid altogidder unproffitable to him be reason that the Stampmylns are buildit hard be the said Lochmylne and the haill watter conveyit fra him to the said Stampmylne. Which soumes underwritten are payit in full satisfaction and payment of the dewtie of the said Lochmyle from the first day of August saxtene hundreth and aucht to the first of May saxtene hundreth and nine yeiris. - £180-0s-0d*"

and ....

> "*To the Baillies of Lynlithgow for ane quarter of ane yeiris payment of the yeirlie dewtie agreit uponn to be payit to thame for thair mylne besyd quhair the Melting and Fyning Mylne standis in respect of the same mylne was altogidder unproffitable to thame during the said quarter be drawing of the watter thairfra to the said melting and fyning mylne. Which soume underwritten is payit in full satisfaction and payment of the dewtie of the said myln from the first day of August saxtene hundreth and aught to the first day of May sixtene hundreth and nine yeiris. - £90-0s-0d*"

Other landowners also received similar compensation (see Appendix 1).

PROBABLE LOCATIONS

The Ordnance Survey map of 1855 indicates the Loch surface level to be close to 150 feet A.O.D. and, in consequence, the '*wayfare*' would have closely followed the 150 foot (46 metre) contour. Taking account of the duration of construction and the above compensation references, it is reasonable to conclude that the stamp mill location was beyond Colt Hill, probably about 500 metres downstream from the Loch, close to the present-day Loch House which lies to the north of Loch Mill. The melting mill was probably a further 300 metres or more to the west, immediately south or west of Pepper Hill close to Little Mill (see the map at Fig.2).

It is of note the former site is adjacent to what appears to have been a spoil dump, just south of Loch House, as shown clearly on aerial photographs taken in 1960 and 1971 (see Fig 3). There are no present-day surface indications of any works at either of these locations, or indeed along the considered line of the water channel. It is of course, some 380 years since their use, but visible remains still exist at Hilderston, and sub-surface investigation may yet show some signs. Disappointingly the spoil dump was removed by construction of the M9 Motorway

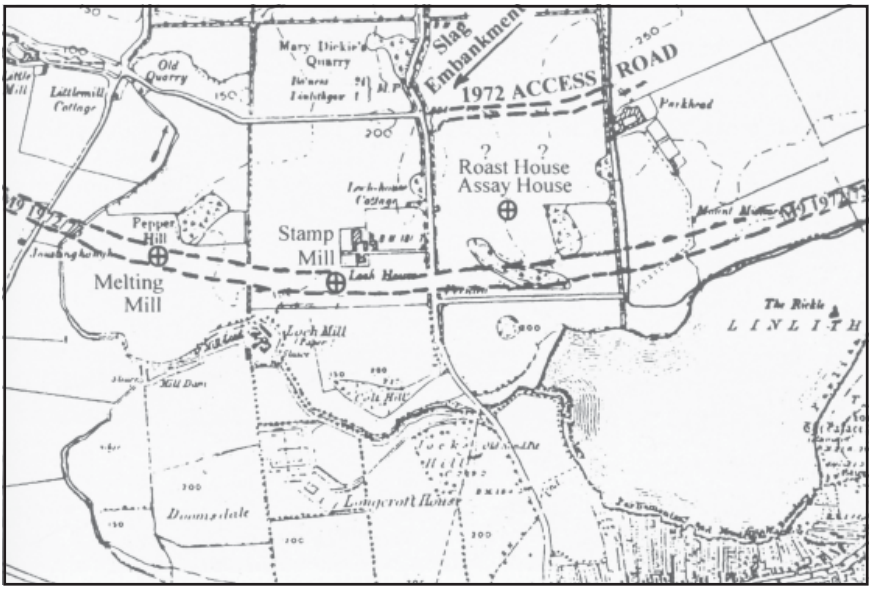

Fig.2 A compilation of the O.S. 1/10560 sheets for 1855 and 1895, showing the probable locations of the mills and the route of the M9.

in 1972/3 so obliterating possible signs of early operations there (see also Fig 2). The spoil dump, if such it was, may well have consisted of metal ore or slag. The possibility remains that traces of the early builderwork may be found in the old farm buildings of Loch House since these are close to the probable sites of the smelter mills and '*old remains*' may well have been adapted or incorporated in these later buildings.

At this point it is appropriate to refer to the anomaly of two other larger and more unusually-shaped, dumps on the hillside, 200 to 300 metres to the east and between 100 and 200 metres north of the Loch, both delineated on the early 6" OS maps (see Fig 2), and which also show clearly on the aerial photos referred to, but which were also removed by motorway construction, (Figs 2 & 3). Nonetheless, it is very likely that these dumps were used to form an embankment for the new access to Parkhead Farm to replace the original access about to be removed by new construction. The anomaly is that smelter slag, apparently related to Hilderston ore, has been recovered from both sides of this new embankment and seems to indicate that these two dumps did, at least in part, consist of smelter slag. Why they were situated away from the two other presupposed locations remains unanswered, however, unless this is the site of the roasting house and assay house where further roasting furnaces were constructed, as entries in later accounts indicate. These buildings may have been on this hillside to take advantage of increased chimney draught, despite having no supply of water to drive bellows, which may in fact have been hand operated.

Fig.3 Aerial photograph of the area shown in figure 2. Taken May 6th 1960, Scale 1/10,500. (Crown Copyright/MOD).

MILL CONSTRUCTION

Following transfer from Leith, Stevin Mon and his son, Johne, worked in a rented cellar in Bo'ness, while the other two wrights worked at Linlithgow on construction of temporary storehouses at both mill sites. These were required for on-site storage and protection of timber and other materials delivered via Bo'ness. They also provided shelter and further workshop facilities for advance preparation of materials required for the permanent works.

Two quarrymen started during Week 2, producing stone for the site from a nearby quarry. During Week 4, two others started producing larger building stones from a more distant quarry, near Avon Water, assisted by two labourers.

On September 4th (Wk.4), James Gray, master mason, with five other masons, began building work, and delivery of the stones from Avon Water quarry started a week later. Production of stone continued from both quarries and the master mason gradually increased his workforce to 13 masons, with two barrowmen and a man making and carrying mortar, by early December (Week 16). Work on the melting and the stamp mills as progressing, and the foundations for the melting mill chimney were already laid. By Week 23 the masonry squad had increased to 12 plus the master, with four barrowmen and two mortarmen. The wrights finished fabricating axles and mill wheels at Culross by Week 12 and they were shipped, along with the wheels etc to Bo'ness to begin work on site at Linlithgow. The small fall from the surface

of the loch to the mills suggests that the waterwheels were of relatively small diameter and of the undershot type, with paddles instead of buckets.

The millwright force at Linlithgow grew to 11 by Week 19, and by Week 22 there were 12 of them at work on the mills engaged primarily on installing the millwheels with their large axles, along with the two large bellows for the furnaces, and then installing the stampers (probably eight in number), with their troughs at the stamp mill, followed by washing table construction until the beginning of April. The main works being by then completed, Stevin Mon returned to his home in Keswick, while his son John remained, but transferred to supervise washing of the crushed ore at the tables which had started the previous week. Washing table construction continued in addition to working on the timber roofs for both mills until completion at the end of April, after which only two wrights were retained on site.

The masons had continued work and as the main walls of both mills were completed by week 25 and the builderwork virtually complete, the Mastermason and most of his tradesmen left the site, leaving behind four masons to dress blue-stones and complete two furnaces in the melting mill, where the timber extension for its single chimney had been put in place by the wrights. About mid-March work was started on the assay house and roasting house and these were completed by April 23rd.

Refractory clay from Tranent, the Grange and Culross was used to make '*stoif*' to set and line the furnaces, while large '*blue stones*', probably highly siliceous ganister, from the same locations, were employed for the foundations, internal bases and walling for these furnaces. Special stones described as 'marginsat' and possibly blackband ironstone, from Water of Devon in Kinross were also used, but presumably along with the furnace charges.

THE GERMANS

In October 1608 King James had reached agreement with his cousin, the Duke of Saxony, to send men with experience and expertise to achieve the best possible results at the smelter works, and the following entry appears in the Accounts for Week 26 (5th-12th February 1609).

> "*At command of The Right Honorable The Earle of Dunbar. Lord Governor of the Mynis, the sums of money underwritten are paid for defraying the charges of the Germane Mynders sent by the Duke of Saxony, for their coming into Berwik till their coming to Linlithgow.*"
>
> "*Germanes - To Henry Starky, Overseer of the Workmen for a months wages advanced to him and to Hans Hawes his Assay Master, Philip Brand, Meltar and his son David, Hone Carpentar, Crystopher Smyth and Jasper Hartsik, Mynders, according to the rate sett down by the King's Majesty and the Lords of His Highness' Most Honorable Privy Counsel of England. £344-18/-*" "*To the said Henry Starky for his*

own wages and for those of the Germanes abovewritten for this week. - £79-7-3" "For sevin posthorses and a guide to the said Journey and to Henry Hovernour, their Interpreter, to ride from Edinburgh to Linlithgow. - £13-16/-"

"*For sevin horses hired to the said Germains and their Interpreter to ride to the Mines uponn the 11th day of February. - 53/4*"

"*To – 'Romero'* [sic] *and another Dutchman for defray of his charges in Edinburgh before his riding to Linlithgow. - £36-0/" "To three horses to him, his friend and guide from Edinburgh to Linlithgow. - £5-8/-"*

During Week 27 (12th-19th February) the following entries occur. "*Hire of four horses for Henry Starky with his Meltar, Assayer and Interpreter to ride from Linlithgow to the Mines to meet the Lords Commissioners on 13th February. - 32/-*" and also "*To Romero, Dutchman for his expenses in Linlithgow and also for his man for the space of 10 days preceding 20th February. - £14-11-4*"

In the week following (No 28) this entry is noted: "*For James Achesone to make his own and Romero's charges, being directed from Linlithgow to take a view of the* [copper and lead] *Mines in Menstrie Glen. - £12-0/-*"

In Week 29 this most unusual entry appears:

"*For getting and carrying two loads of copper slag from the Silver Mill near Edinburgh* [Leith?]*, to the Silver Mill near Linlithgow. - 50/-*"

INITIAL SMELTING

After arriving in Scotland, Starky and his workmen, as noted, met the Lords Commissioners by appointment at the mines, and no doubt received permission for the operation of the '*Melting, Fining and Stamp Mills*' in the manner Henry Starky considered most productive, in agreement, of course, with James Achesone, the '*Master Fynnar*'. Throughout the following three weeks, they were mainly engaged in arranging for the special tools and other ironwork necessary for their work. At that time, instructions were given for delivery from the stockpiles at the mines, of the quantities of washed/crushed ore immediately required for the melting mill, and for later delivery of untreated ore to the stamp mill. Work was also put in hand for the preparation of the '*stoif*' from clay, straw and bone-ash for furnace setting, and for necessary deliveries of lead (2 sows), peats (37 loads), charcoal and coals (84 loads), perhaps along with the copper slag, for initial charging of the furnaces.

During the week of March 5th to12th, (No.30), one furnace was being charged, and the first "*melting*" operation was started the following week, as indicated by provision of timing candles to the meltar, and subsequently wine, ale and bread to him and his workmen to mark that commencement. Further quantities of red clay, lead and coals, along with 'tiled'-stones (fireclay bricks), were also being delivered to the melting mill.

At the same time, it is noted that iron slag was gathered from the sands near to Culross although there is no known explanation of how such material came to be there, unless perhaps it was ballast removed from a ship. This slag was sent in two separate consignments to the melting mill, as called for by the Germans. Likewise, quantities of a material described as '*marginsat*' was won by pickmen at the Water of Devon and nearby Caldronmire (or Caldermuir?), Kinross, and transported at three different times to the mills, as also called for by the Germans. This material, it is believed, may be blackband ironstone, which is understood to occur in that area. It was presumably employed with the ore etc as part of furnace charges, either separately, or along with the lead and iron or copper slags already referred to.

Further meltings took place during Week 32, consuming 15 loads of coal, while during Weeks 34 and 35 melting was again in progress, consuming four loads of charcoal and 42 loads of coal. Two sows of lead were also delivered then.

In the three weeks from mid-April, 46 loads of coal went to the melting furnaces, while 10 loads of red clay were used to make *stoif* for melting and assay furnaces, and later a further quantity was used to make *stoif* for the roasting house.

STAMPING & WASHING

As already noted, two washing tables were in use along with the stampers during Week 33. A third was added the next week, followed by a fourth in Week 36, and a further two a week later to make a total of six.

Seventy horse loads (in barrels of about 560 to 600 lbs each requiring 2 horses), of ore were sent to the stamp mill during Week 35, with 13 loads of dressed ore to the melting mill. In the next week 91 loads were sent to the stamp mill, with a further 96 loads a week later (No.37). This confirms that both the stamp and melting mills were operational, and probably in full commission, by the beginning of May 1609.

By early August 1609 there were nine workers on the washing tables, with four others at buddles and sieves. Two ordinary workmen attended the stampers, one served the washers, another minded the sluices and three helped the melters. The roasting house was in use, and received 13 loads of coal, while four masons spent five days re-building "*fining furnaces*". At the same time 33 loads of '*washed metal*' were carried from the stamp mill to the melting mill storehouse, while 148 loads of '*fresh metal*' were delivered from the mines to the stamp mill. The next week saw 12 loads of '*washed metal*' were transferred to the storehouse, while a further 129 loads of '*fresh metal*' came from the mines.

GENERAL OBSERVATIONS

The following entries in the accounts for Week 30 are of interest:

> "14 loads of common clay to make the chimney of the Assay Furnace. - 18/4"
> "For straw to work with the same clay. 8/-",

"For ploughshare nails for the head of the chimney of the same Furnace. - 12/-",
"For door nails for the same chimney. - 6/8",

and

"For a man going to the Mines to cause the bringing of metal to the Mills. - 3/-"
"For 4 loads of peats at 4/- the load and another 23 loads at 6/- the load for the Melting Furnaces. - £7-14/-"
"For 200 flooring nails to divide and prepare one end of the Melting Mill workhouse to receive that metal coming from the Mines and also from the Stamp Mill. - 36/-"

Entries give an insight into other aspects. For example Martene Smeddell, a Dutchman, lived in Linlithgow from his arrival until the end of February 1609, when he moved into the house built for him at Hilderston. Fourteen other entries record horsehire for him to ride from Linlithgow to the mines (either 6/8 or 5/- per day), generally once a week. Eight different entries also refer to horsehire, but these are for visits to Edinburgh (26/8) to Airth (12/- or 10/-), to Torwood, Torphichen, to examine growing timber, to Bo'ness to take boat to Culross (14/- for horse and boat) for discussions with George Bruce (twice), and also to the lands of Killeith (26/8), to meet two miners engaged in prospecting over a period of about eight months. This was probably in the upper reaches of Water of Leith near Kinleith, near Balerno and Currie where copper and lead veins were later worked. He later spent two days trying other mines, possibly in Menstrie Glen, with a German, Konig Alsont [sic] (each 20/- per day).

CONCLUSIONS

Regarding the foregoing mention of an assay furnace, no specific indication of a location appears and so it may have been within the melting mill. Alternatively perhaps it perhaps was the assay furnace constructed for James Achesone, though that would undoubtedly restrict, or conflict with, the work of Hans Hawes, Henry Starky's assaymaster. However, the hillside above the Loch some 200-300 metres to the east has already been postulated as the probable site for the assay and roasting houses, and there appears no good reason to assume otherwise. From the accounts it appears that the melting mill contained at least two melting furnaces and one refining furnace, as well as a stamping trough for bone ash treatment connected to a timber lean-to outhouse where the bone ash was stored. Is thought that there was at least one, or maybe two, waterwheels driving at least two large bellows and the stampers. The stamp mill is considered to have had one waterwheel, with double axle, driving at least eight stampers, feeding washing troughs, tables, and later, buddles, sieves and tubs.

The summary of building materials etc in Appendix 2 indicates the scale of the works, but not the complexities of the planning and control required, as is shown by the detailed accounting involved, and summarised above from the 120 pages of accounts from May 1608 to May 1609. Some speculation was used to estimate tonnages of

masonry etc, which were recorded as loads. These are thought to have been manloads, since horse charges are entered where involved. In these terms a manload is considered to have been 80-100 lbs avoirdupois depending on the distances involved and nature of the material, while a horse load, was 280-300 lbs, calculated from old units of measurement and the quantities of lead, lime etc and other materials noted in the appropriate account entry.

THE FINANCIAL ASPECTS

COSTS

Expenditure on the mills and associated works from May 1608 to May 1609 amounted to £20,135 10s 10d Scots, including £2,479 6s 0d in respect of annual fees, compensation charges and other expenses. The costs incurred in England by Craig and Achesone, totalling £6,687 13s 7d Scots prior to August 14th 1608 has already been noted. The weekly charges from March 26th 1609, when smelting began during Week 33, amounted to a further £1,326 1s 5d Scots, leaving a remainder of £9,642 9s 10d Scots as the actual on-site construction cost of the mills etc. That equates to an average weekly outlay of £301, compared with the average of £221 for the succeeding six weeks when melting and stamping operations were apparently in full operation, and £204 per week for the two weeks in August 1609 which were also examined.

RETURNS

Examination of accounts for melting and stamping operations gives the approximate weight of ore transferred from the mines to the stamp mill or directly in the melting mill, and these are set out in Appendix 3. The approximate loss of weight washing etc at the mines and stamping at Linlithgow was about 60% and, on that basis, the total tonnage of undressed ore treated during an eight week period would be about 120 tons.

Based on the Lord Advocate's declaration of November 1608, and the recorded weight of silver coined by George Foulis, the rate of silver recovery then was about 31 lbs weight of clean silver per ton of ore, and on that basis approximately 3720 lbs of silver would have been recovered from the ore delivered to the Melting and Stamp Mill during that period.[2]

The value of the silver supplied to be tested for gold-content by "*fining with watter*" (granulated with salt in water prior to heat treatment), is entered as 53/4d per lb, and at that rate the silver recovered from that tonnage would have had a value of about £9,920 Scots for the above-mentioned period, auguring well for a very successful outcome to this mining venture.

The costs incurred at the mines have of course also to be taken into account. The overall total cost to May 7th 1609, including the operation of the mines is stated to have been £45,838 4s 0d Scots, and, with ongoing costs approximating to a combined weekly amount of about £514, a credit balance would not have been achieved until at least June/July 1610, always provided the richness of the ore had not diminished.

The several trials made on the ore sent to England gave conflicting results, and while the result of the assay carried out at the Tower of London approximated closely to the Lord Advocate's stated recovery rate, others elsewhere gave very low values. It must be stressed that the above assessment of silver recovered over an eight week period is largely speculative and must be treated as such, the quality of the ore could vary and random sampling for assay may explain differing results. It seems certain from the records, however, that ore quality and silver production did fall away over the succeeding year or so, to the point where the King's Advisers eventually welcomed the take-over proposed by Sir William Alexander, Thomas Foulis and Paulo Pinto.

Undoubtedly there will be records available of the silver production from Linlithgow, and the most likely source may be in the records of Coinage of the Master Coiner, or those of Thomas Foullis, Goldsmith, the Master Refiner appointed by the King. These sources have not been pursued by the author.

SUMMARY

These Silver Mills Accounts, transcribed from the original of 1608/09, condensed and summarised above, albeit in narrative form, together with the history of the Mines at Hilderston recently published, provide an insight into the early 17th century mining and recovery of silver in Scotland.[1] Unfortunately however, there is apparently no record extant of the actual methods used for smelting at Linlithgow, though at may be that a reference was recorded in the Hechstetter Memorabilia and Letters of 1600-1639 in view of the consultations between James Achesone and the German immigrants at Keswick, followed by Emanuel Hochstetter's six weeks stay in Linlithgow.[3,4]

SLAG EXAMINATION

Examination of the fist-size pieces of slag recovered earlier from Hilderston, along with the, more recently, material collected near to the likely site of the Silver Mills at Linlithgow, is of special interest.

Three distinct forms are noted and have been classified as tan, grey and black, each with differing characteristics and understood also to differ substantially from the lead etc smelter slags of England, or indeed Leadhills/Wanlockhead in Scotland. Surprisingly those specimens examined exhibit little or no sign of metallic residues common to those other slags.

Preliminary examination by scanning electron microscope (SEM), energy dispersive analysis (EDX), and powder Xray diffraction (XRD), has been carried out on specimens of both the tan and the grey material with some interesting results. Detailed descriptions of these slags, along with their test results are now, however, given separately elsewhere and dealt with in detail by Smith and Meikle (in process), with a view to determining the likely smelting process adopted by the Germans in dealing with the reduction at Linlithgow, of the complex Hilderston silver ore.

APPENDIXES

Appendix 1

Regarding earlier references to compensation payments, the following further entries are also noted:-

Week 36 – "To John Hamiltoun in satisfaction for the breaking of his ground to cast fill on it for the damming of the water at the Loch Mouth - £3-0/-"

Week 38 – "To a boy for carrying a letter to Mr John Bruce and another to Mr Alex. Hamiltoun desiring them to keep tryst with the Earl of Linlithgow for appraising of the loss sustained by the gentlemen owners of the ground whereupon the melting and stamping mills are built."

To the inhabitants of the Burgh of Linlithgow, owners of the 'yards' upon the Loch thereof for the loss sustained by them in damming of the said Loch whereby the 'yards' were drowned by the overflowing thereof where the same losses were prized by honest men of the said burgh 'chosen for the same purpose' - £150 0s 0d"

"To Mathew Gray in compensation of the loss sustained by him by treading down of his land with the carts that carried stones to the Stamp Mill after the said lands were tilled – 26s 8d"

"To John Rait, Smith, for licence to cast fill on his land for building the mill troughs and for loss sustained by him by the overflowing of the Loch upon his land - £6 13s 4d"

The following unusual entries appear at the end of the accounting period and are considered to relate to tests performed to establish a possible gold content in the silver being recovered from the smelting etc operations at Linlithgow.

"*To Mr John, Englishman that undertook to 'fine the mettal with watter' by warrant of the Lords Commissioners for the Mines - £66 13s 4d*"

"*For ten pound weight of which silver to him at 53/4 the pound - £26 13s 4d*"

"*For five 'laine' pots to him – 16s 8d*"

Appendix 2

Building Materials - August 1608 to May 1609

Lime	-	36 chalders		=		36 tons
Sand	-	1134 loads		=		50 tons
Stone	-	Local quarry	- 13,312 manloads	=		600 tons
		Avon Water quarry	- 148 manloads	=	say	6½ tons
'Blue' stone	-	Tranent/Culross/Grange	- 135 manloads	=		6 tons
Clay	-	Common, for trough setting	- 30 manloads	=		1½ tons
		Refractory, for furnaces	- 55 manloads	=	say	2½ tons
'Marginsat' (ironstone?)	-	115 loads		=	say	5 tons
Iron slag	-	3 Horseloads		=		8 cwts
Copper slag	-	2 load		=	say	2 cwts
Lead	-	80 sows (1 sow = 2½ cwts)		=		10 tons
Timber	-	Broad Oak Planks	- 12 No.			
		Great Oak Trees	- 128 No.			
		Large and small Fir Trees	- 256 No.			

		Single Roof Spars	-	124 No.
		Double Roof Spars	-	53 No.
		Deal Boards	-	6,250 No.
Ironwork	-	Stampers	-	18 No. (probably = 9 + 9 spare)

Plus a multiplicity of ironwork as nails, bands, clamps, hinges, guards, guides etc. Specialised Tools, Instruments and Furnace Fittings - eg. Bundles of Iron Platters - 431 lbs wt.

8 Iron	Melting Pots - 362 lbs wt.
9 doz.	Big Melting Pots
11050	Small Melting Pots
6 doz.	Trays or Troughs - varying size
3	Large Scoops
12 pr.	Hand Bellows - varying size
3 doz.	Spades & Shovels
16	Sandglasses (1, 2, 3 & 4 hour duration)
Sets of	Weight Measures (Bell Metal & Brass)
1	Large Iron Cape, 1 Ingot Mould, 2 Furnace Hinges,
4	Buckering Plates and 2 Mortars - all manufactured in Sussex Ironworks - cost £420 8s 0d

Appendix 3

WEEKLY EXPENDITURES

Week No.	Event		Amount £	s	d
26 (5-12 Feb)	German Party arrives		831	7	1
27			644	6	10
		Total	1483	14	9
		Average	742		
28			280	19	1
29			216	16	3
30			281	17	3
31	Henry Craufurd leaves		264	7	1
32			301	16	5
		Total	1345	16	1
		Average	269		
33	Stampers etc in use		264	12	5
34	Stevin Mon leaves		268	17	3
35	Nominal Mason & Wright presence		233	16	4
36			214	14	3
37			168	10	11
38 (30 Apr-7 May)			175	10	3
52 (6-13 August)			196	17	4
53 (13-20 August)			211	8	6
		Total	1734	7	3
		Average	217		

ORE TRANSFERS AND DELIVERIES

(Loads are Horseloads considered 300 lb approx.)

Wk 29-30 (1-12 Mar)	24 loads of washed metal considered as 1st Melting - about 3 tons	=	7½ tons ore
Wks 31-33 (12 Mar-2 Apr)	49 loads ore	=	6½ tons ore
Wk 34	53 loads ore		
Wk 35	13 loads to Melt Mill - say 1¾ tons	=	4½ tons ore
	74 loads to Stamp Mill	=	10 tons ore

Wk 36	91 loads - say 15 to Melt Mill - say 2 tons	= 5 tons ore
	and 76 loads to Stamp Mill	= 10 tons ore
Wk 37	96 loads - say 20 to Melt Mill - say 2.5 tons	= 6 tons ore
	and 76 loads to Stamp Mill	= 10 tons ore
August 1609 -		
Wk 52	33 loads from Stamps to Store - say 4.5 tons	= 11 tons ore
	148 loads from Mines to Stamps	= 20½ tons ore
Wk 53	12 loads from Stamps to Store - say 1.5 tons	= 4 tons ore
	129 loads from Mines to Stamps	= 17 tons ore

Total Equivalent of Untreated Ore equals - say 120 tons

Appendix 4.

Early entries from Volume Two of the Accounts are believed to provide a good outline of the regular procedures being employed with the Smelter Works in full operation, as outlined by the following detailed transcriptions.

Ae Weeklie Accompte of All Money Debursit in Ordinary Chairges and Uponn Materiallis and Uther Extraordinary Uncoistis for the Kinges most excellent Maiestie his Mylnes besyd Linlithgow fra the Saxt day of August the year of God (1600) and nyne yoiris to the fyft day of August (1600) and ten yoiris. As thair accomptis wherfor written taken up weeklie be Sr George Bruce of Carnok Knycht Thesaurir of his Majesteis Mynis and Archibald Primrose Clerk of the same Mynis more particularlie borris.

Fra the Saxt day of August to the xiij day of the same

ORDINAR EXPENSS

GERMANIS To Henry Starky Overseer of the Germanis for his ane wagis and for the wagis of Hans Hawes his Assay Master Philip Brand melter and his sone David Hone Carpentar Cristopher Smyth and Jasper Hartsik this week ... lxxix'Li vij's iij'd
To Henry Starky for his horsmeat this week according to the condition set doun wyth him ... iij'Li vij's

WRYCHTIS
To Johne Balfour for sax dayis wark at xiij's iiij'd a day .... iiij' Li
To Patrik Ferrier for sax dayis wark at x's a day ... iij' Li

MASONIS
To James Britt for fyve dayis wark at xiij's iiij'd a day ... iij'Li vj's viij'd
To Patrik Bryer for fywe dayis wark at x's a day ... 1's
To Wm Bryer for fyve dayis and ane half dayis wark at x' a day ... lv's
To Thomas Fairlie for four dayis and ane half dayis wark at vj's a day ... xxvij's

WASCHERIS at the WASCHEING TABILLIS
To Johne Mon for sax dayis wark at xvj's a day ... iiij'Li xvj's
To Nicol Achesone for sax dayis wark at xiiij's a day ... iiij'Li iiij's
To Isaac Webber for sax dayis wark at x's a day ... iij'Li
To Bernard Bonny for sax dayis wark at x's a day ... iij'Li
To Arthur Fairlie and Wm Balb? aither of thame haveand daylie for sax dayis viij ... iiij'Li xj's
To Harry Bannatyne for sax dayis wark at vj's viij'd a day ... xl's
To Robert Burns for sax dayis wark at vj's a day ... xxxvi's
To James Wilson for sax dayis wark at v's a day ... xxx's

WASCHERIS at the BUDDILLIE and SEIV
To James Wiliams for sax dayis wark at x's a day ... iij'Li

To Wm James for sax dayis wark at viij's a day ... xlviiij's
To Thomas Hyslop for sax dayis wark at vij's a day ...xlij's
To Francis Burk for sax dayis wark at x's a day ... iij'Li

ORDINAR WARKMEN
To Johne Gib for sax dayis in keping the Stampers at v's in the day ... xxx's
To James Lapsley for sax dayis in tryming the Stampis at vj's in the day ... xxxvj's
To Johne Burgamann for serving the Wascheris ... x's
To Johne Findlay for sax dayis in keping the slouss at v's in the day ... xxx's
To Johne Borthwik for sax dayis at the Melting Mylnis at vj's viii'd a day ... xl's
To Eduard Myrhinn for sax dayis at the Melting Mylnis at vj's viij'd a day ... xl's
To Thomas Aitkin for sax dayis at the Melting Mylnis at vj's a day ... xxxvj's

To James Glen Greve for his wagis this week ... iiij'Li
To Robert Brice Interpreter to the Germanis ... v'Li
To Patrik Kyle in Borrowstounnes for the maill of his feed selleris hyrit for the keping of all materiallis broht be sea to the mylnis ... xxvj's viiij'd

Soume i'c lvij'Li ij's vij'd

MATERIALLIS AND UTHER EXTRAORDINARY UNCOISTIS
For xiij loadis of coillis tae the Rosting Hous at v's the load iii'Li v's
For carying the same coillis fra the grangthouth (Grangemouth?) to the mylnis at ij's viij'd the load ... xxxiiij's viij'd
For twa bollis of lyme tae to the fynning furnacis at iiij's iiij'd in the boll ... viiij's iiii'd
For carying sax loadis of lyme fra Linlithgow to the mylnis for the fynning furnacis ... iiij's
For aiht loadis of sand to the lyme ... viij's
For four quartis of ail to the Masonis warking at the fynning furnacis at ij's viii'd a quart ...x's viii'd
For ane barroll of ail and small drink mixt together to work the bone ashe for the fynning furnacis ... xij's
For ane pynt of oyl to the wyxdrs of the axthers of the wheles ... xij's
For thread to mend the wasching clothis at the mylnis ... viij's
For fourty naillis that standit befor the graittis of the stampers ... iij's iiij'd
For carying of ane sow of lead fra Borrowstounnes to the mylnis ... v's
For carying of twa barrolls of bone ashe fra Borrowstounnes to the mylnis ... x's
For carying of xxxiij loades of waschit mettell fra the stamping mylnis to the storehous at the melting mylnis at viij's the load ... xxij's viij'd
For carying of sevin score aiht loadis of mettell fra the mynis to the stamping mylnis at iiij's the load ... xxix Li xij's
For ane hors hyre to the mynis with Hand Hawes the Assayer ... vj's

Soume xxxix'Li xiiij's ix'd

Soume of the haill money debursit this week in ordinary expenss and uther uncoistis for the mylnis and warkis . j'c lxxxxvj'Li vij's iiij'd (£196 7s 4d)

and from the week followlng ....

Fra the xiij day to the xx day of August.

ORDINARY EXPENSS

GERMAINS To Henry Starky Overseer of the Germains for his ane wagis and for the wagis of Hans Hawes his Essay Master Philip Brand Meltar and his sone David Hone Carpentar Cristopher Smyth and Jasper Hartsik Mynders ...

To Henry Starky for his horsmeat this week according to the conditions sett down with him ...

WRYCHTIS
To Johne Balfour for sax dayis wark ...
To Patrik Ferryar for sax dayis wark ...

WASCHERIS at the WASCHEING TABILLIS
To Johne Mon for sax dayis work ...
To Nicoll Achesone for sax dayis wark ...
To Isaac Webber for sax dayis wark ...
To Bennet Bonny for sax dayis wark ...
To Arthur Fairlie and Wm Bowes ather of thame haveand ... daylie for sax dayis wark ...
To Wm Buntente for sax dayis wark ...
To Robert Burns for sax dayis wark ...
To James Wilson for sax dayis wark ...

WASCHERIS AT THE BUDDILE and with the SEIV
To James Williams for sax dayis wark ...
To Wm James for sax dayis wark ...
To Thomas Bisope for sax dayis wark ...
To Francis Burk for sax dayis wark ...

ORDINAR WARKMEN
To Johne Gib for sax dayis keping and filling the stampers ...
To James Lapsley for sax dayis wark in trimming the stampers at the Stamping Mylnis ...
To Johne Burgamanin for sax dayis in serving Francis Burk ...
To Johne Borthwik for sax dayis in serving the Meltar ...
To Eduard Ingram for sax dayis wark in serving at the Melting Mylnis ...
To Thomas Arthur for sax dayis wark in serving at the Melting Mylnis ...
To Johne Findlay for sax dayis wark in keping and drawing the slouss ...
To Thomas Polwark for twa dayis wark ...

To James Glen Greve for his wagis this week ...
To Robert Bruce Interpreter to the Germainis ...
To Patrik Glen in Borrowstounness for the maist of his feed sellaris ...

Soume j'c xliij'Li viij's xj'd

MATERIALLIS AND UTHER EXTRAORDINARY UNCOISTIS
For four loades of coiles to melt wlth at v's a load ...
For carying the same coilles fra the Houth to the mylnis ...
For twa new touallis with lidis to the fynning bellowes ...
For laying ane pund weiht of irne uponn ane of the clokes of the melting bellowes with auiht grete naillis therto ...
For drawing of ane stoking irne and mending of it ...
For ane new drawing irne to the fynning furnacis ...
For laying of twa pund weiht of irne uponn ane of the fire trims to the melting furnacis ...
For winning of twelf greate bloa stanes to the fynning furnacis and fraught of the same from Culross to Borrowstounnes ...
For carying the same stanes from Borrowstounnes to the mylnis being ten hors at ij's viij'd the hors ...
For ane barroll of ail and small drink to drink the bone ashe for the fynning furnacis ...
For candilis the tyme of the fynning ...
For ane quarter pund of tallow to Hans the Essay Master for his assay furnacis ...
For ane pynt of oyle to the gudgeons and axteris of the whelis ...
For carying thrie sous of lead fra Borrowstounnes to the mylnis with sax hors at ij's vj'd the hors ...
To saxtene elnis of twill to the wasching tubbis at x's viij'd the eln ...

For xxiiij elnis of twill to the wasching tabilis ...
For ane hors hyre to James Glen to ryd to Edinburg for buying of the twill ...
For carying this twill fra Edbg to the mylnis ...
For mending twa stamp bandis of irne ...
To ane loade of hadder to be bussems to the wascheris at the wasching tabilis ...
For ane bowt of twyne to bind the bussems with ...
For thrie hr.. of twill to be ane boddome to ane wasching seiff.
For ane girth and irne tarkottis to the seiff ...
For ane corse band of irne to the boddome of the seiff ...
For carying of twelf loades of waschin mettell fra the stamping mylnis to the storhous at the melting mylnis at viij's the load. For carying sax score nyne loadis of mettell fra the mynis to the mylnis at iiij's the load ...

Soume xlij'Li xiiij's vij'd

Soume of the haill money debursit this week in ordinar expenss and uther uncoistis for the mylnis and warks -

ij'c xj'Li viij's vj'd (£211 8s 6d)

ACKNOWLEDGEMENTS

Thanks are due to Richard Lamb for guidance in the realm of slag investigation and introduction to early literature with helpful comments concerning early account-entry transcriptions. Thanks are also due to Dr Allan Hall, Dept. of Geology & Applied Geology, University of Glasgow, and to Dr Mike Rothwell, Unilever Ltd., Port Sunlight for XRD, SEM and EDX examinations, as well to Dr Richard Braithwaite, Dept. of Chemistry, UMIST, Manchester and Mr Norman Thomson, Carlisle for IR (Infra-red spectrometry), examinations.

The advice and assistance is also readily acknowledged, of the Staff of both the Historical Search Room and the West Search Room of the Scottish Record Office, Edinburgh in connection with the Accounts of 1608-09, and of the Librarian/ Archivist, National Monuments Record of Scotland (R.C.A.H.M.S.), Edinburgh in respect of Aerial Photographs is also readily acknowledged.

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Paper submitted - June 11th 1996

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