FIELDWORK ON THE SITE OF DUKESFIELD SMELTMILLS HEXHAMSHIRE

REPORT ON ARCHAEOLOGICAL EVALUATION CARRIED OUT IN OCTOBER 2012

by

THE ARCHAEOLOGICAL PRACTICE LTD.

for

THE FRIENDS OF NORTH PENNINES

SUPPORTED BY

THE ALTOGETHER ARCHAEOLOGY PROJECT
NORTH PENNINES AONB

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SUMMARY

This document reports on a programme of archaeological fieldwork, including geophysical survey and evaluation excavation carried out at the site of Dukesfield Smeltmills, on the Allendale Estate in the Parish of Hexhamshire, Northumberland where background documentary work had provided contextual information regarding the archaeological and historical development of an industrial site active from at least the mid 17th century to around 1840, during which time it was occupied by a lead smelting works.

The excavations carried out in October 2012 explored some of the main features of the site visible as built remains, including a run-off leat and chimneys, as well as testing sites thought likely on the basis of historic map evidence to contain built remains..

The results of geophysical survey, undertaken in difficult conditions, did not provide compelling evidence for buried archaeological remains, but this alone does not represent evidence for the absence of such remains. The subsequent excavations were considerably more revealing, providing evidence for a wide range of structural elements some of which lend themselves to secure interpretation, while others present further questions the solutions to which can only be approached by combination of additional fieldwork, materials analysis and documentary evidence.

The evidence provided by excavation indicates that a rich and diverse range of archaeological features survive on the site and that further investigation would add considerably to the fund of knowledge available for their interpretation.

It is recommended on the basis of the evaluation work reported here and supported by documentary evidence that the following elements of the site should be further investigated with a view to public interpretation, consolidation and, in some cases, display:

The area in front of the truncated north elevation of the arches should be investigated by widening and deepening the trench opened in October 2012, with the aim of establishing the extent, depth, character and chronological phasing of remains known to be present there. Specifically, the relationship of the excavated wall remains with the present arches should be established by excavating up to the footings of the arches following suitable consolidation work on the upstanding structure.

The excavation of the leat south-west of the arches should be extended to include the section excavated in October 2012 with an additional section to the west. The purpose of this will be to expose features for consolidation, interpretation and display, and to answer questions about the nature of the water supply to the smeltmills, and to explain changes to this supply over time.

The excavation of the chimney bases should be repeated and extended to include the area between the chimneys and the end of the arches upon which the horizontal flues from the smeltmills rested, with the purpose of exposing features for interpretation and consolidation.

1. INTRODUCTION

The fieldwork reported here will inform the Dukesfield Smelters and Carriers Project, being carried out by the Friends of the North Pennines which aims, through agreement with the landowner, local farmers and grant-making bodies, to restore the arches, reveal the industrial history of the site, and encourage the exploration of the area by residents and visitors. Led by local historian Greg Finch, the FNB has secured a Stage 1 pass from the HLF for the project, which is currently undergoing its development phase, with a Stage 2 application scheduled for submission to HLF in December.

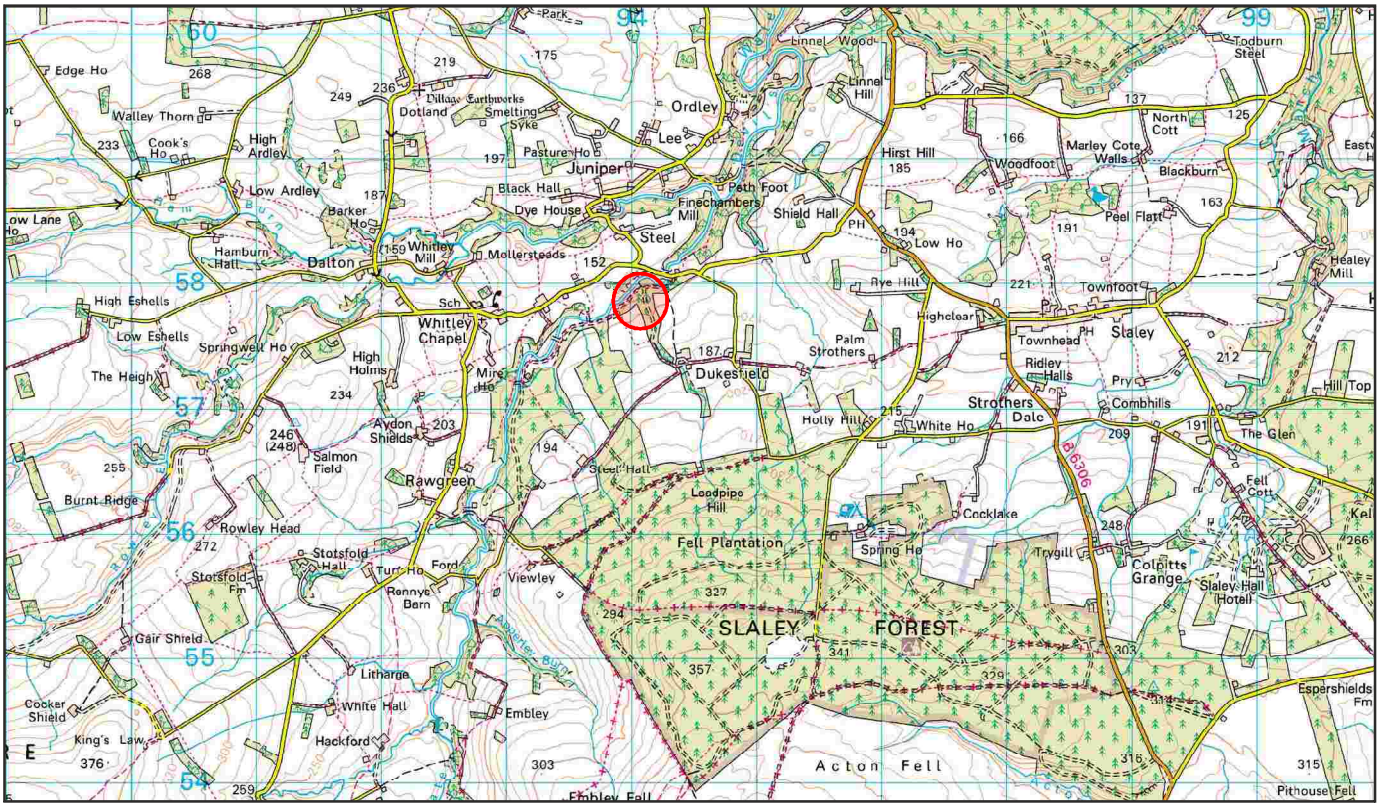
Fieldwork was directed by Richard Carlton of the Archaeological Practice Ltd. and carried out under the auspices of *Altogether Archaeology*, the North Pennines AONB Partnership's community archaeology project, led by the North Pennines AONB Historic Environment Officer, Paul Frodsham. Other professional participants included Marc Johnstone of AP Ltd.; Alan Biggins of Timescape Surveys, assisted by his team of David Astbury, Catherine Mackey and Stephanie Jeffreys; industrial archaeologist Alan Williams; and buildings historian Peter Ryder; while the volunteer team was led by historian Greg Finch, who also carried out and coordinated background historic research into the Dukesfield site. Other advisors to the project included Ian Forbes, formerly directory of Killhope museum, who visited the site in order to offer advice on two occasions. Thanks are also offered to the landowner, Allendale Estates, and the tenant farmers, Andrew and Kath Swallow, who provided valuable local knowledge to the project team and aided them by backfilling several of the trenches.

1.1 Purpose of Evaluation

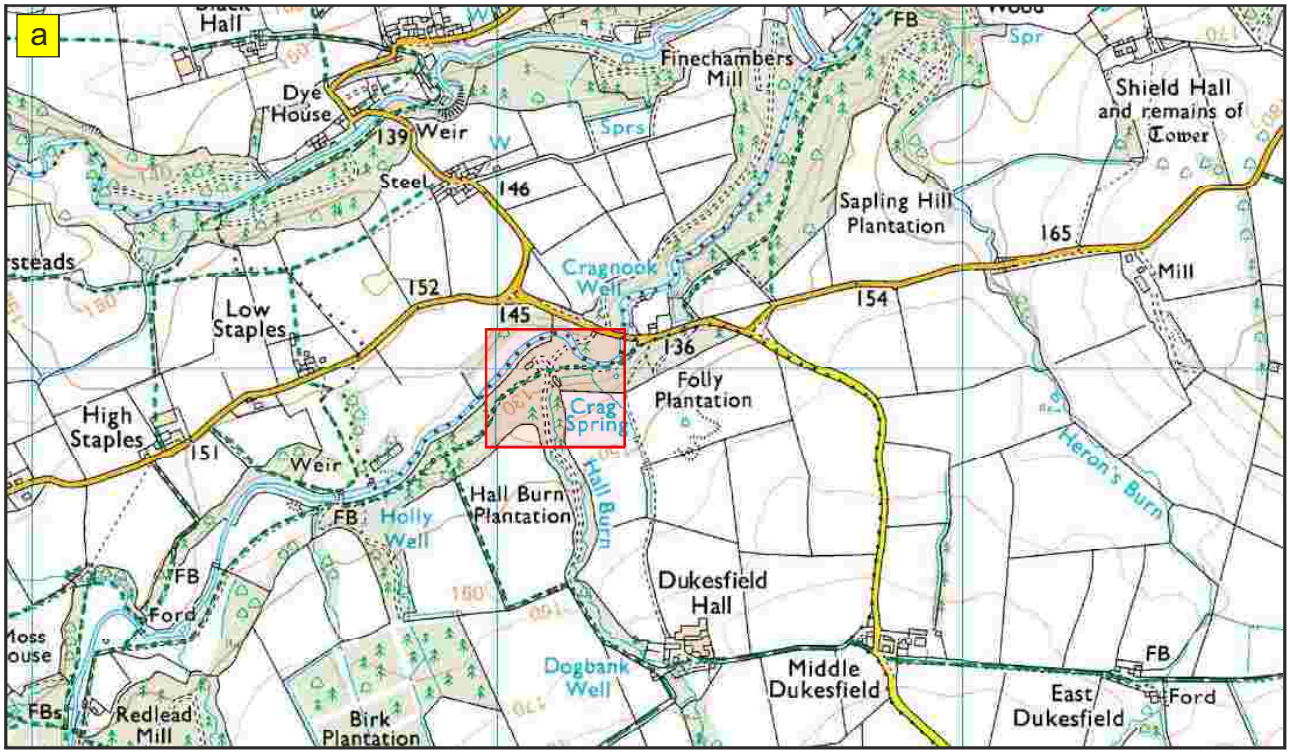
The following is a report on a programme of archaeological evaluation trenching carried out on the site of a late post-medieval and early modern industrial complex at Dukesfield, on the Allendale Estate in the Parish of Hexhamshire, some eight kilometres south of Hexham Northumberland, centred on NGR NY 942580. The site sits upon a narrow haugh between the south bank of the Devil's Water and a wooded bank running up to Dukesfield Hall at West Dukesfield. The Hall burn, which runs northwards towards the site from the hall, is diverted through the stone and brick arches which form virtually the only upstanding remains of the former leadworks. The excavation strategy did not directly concern the arches themselves, but was designed to explore and define the nature of previously known and suspected buried features of archaeological significance adjacent and related to them.

During the course of fieldwork the opportunity was taken to visit various other sites of contextual significance to the Dukesfield smelt mill site, notably the site of dams, on the Devil's Water upstream of the smelt mill site, off which the main water supply to the mill was taken, and West Dukesfield (Dukesfield Hall), residence of the mill agent, where contemporary buildings survive - including a detached bothy used to stable carrier ponies with sleeping space above for their drivers - along with the remains of an adit driven into the burnside in search of coal, and many re-used hearth stones taken from the smelt mill. A search was also made for the Halleywell Spa, an ancient holy well which still served as a meeting place during annual community picnics into the early twentieth century and is shown on historic maps as a 'Spa Well', but is now lost in the undergrowth adjacent to the south

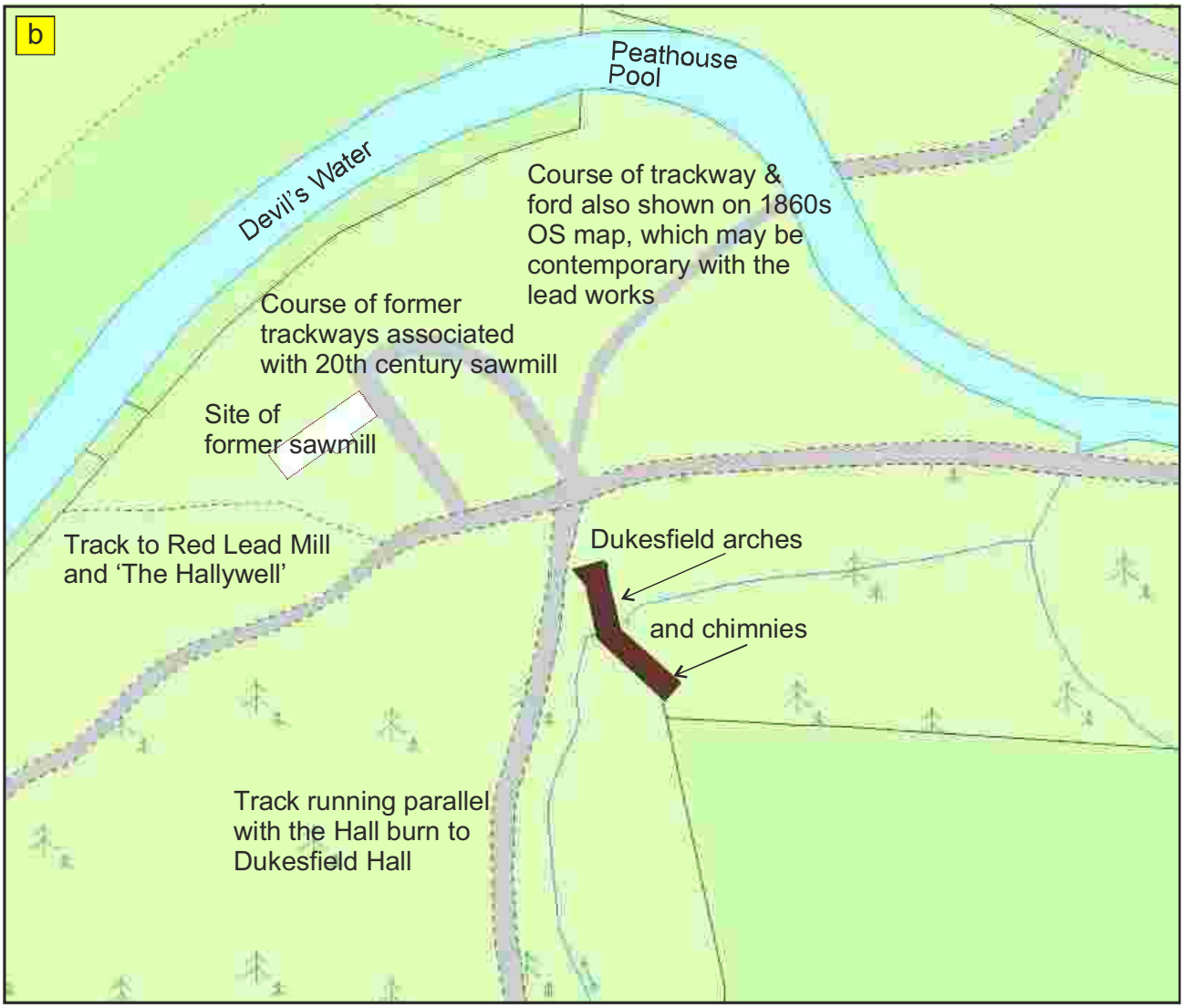
***Illus. 01**: The Location of Dukesfield south of Hexham.*



***Illus. 02**: The Location of the Dukesfield leadworks site east of Whitley Chapel and west of Slaley.*



***Illus. 03 & 04**: The Location (03: above) and layout (04 :below) of the Dukesfield smelt mill site as shown on modern Ordnance Survey plans of the area.*



side of the 'New Dam' on the Devil's Water. A short walk upstream of the New Dam is the site of a Red Lead Mill (at NGR NY 932575) noted in a deed from as early as 1671, which is now the site of a small 19th century keeper's cottage on a raised pasture terrace above the river haughs, with the footings of a second small building and attached enclosure on a north-south axis just above the river to the north. The site was also described as a lead mill in a deed of Steel Hall estate in 1686, but it seems likely from the form adopted in a later deed of 1751 that the site was by then no longer in use for lead processing. The adjacent ground next to the river was still named 'Silverhaugh' on the first edition OS map; however, referring to the process by which Red lead is created from litharge, the by-product of re-smelting lead for silver.

Prior to the current scheme of investigation, few features were visible within the Dukesfield smelt mill site other than the arches themselves and the course of the leat from the 'New Dam', which is traceable for all but the first part of its course as it runs along the north-facing valley side towards the Hall Burn, which it enters via a short culverted section. The modern trackway parallel with the Devil's Water runs next to disturbed ground (the site of buildings shown on the 1802 plan) on the north side of the Hall burn, while between the track and the river is an area overgrown with light scrub and pines, within which are various earthwork features and traces of stone masonry, some of which are the footings of buildings shown on the 1802 plan, while others may be the result of disturbance caused by a later saw mill and its supply tracks.

1.2 Cultural Heritage Background

[NOTE: Much of the following was contributed by, or draws upon, extensive research carried out by Greg Finch and colleagues from the *Friends of the North Pennines*]

Dukesfield and Red Lead Mill are two of a cluster of at least five currently known lead smelt mill sites in Hexhamshire dating from the mid-late 17th century. Their position some 3 miles north of the nearest lead veins means that they used ores brought in from Allendale and Weardale, although the cost of this was offset by the ready availability of wood and relative ease of onward transport. Lead smelting appears to have been long established in the area: lead slag remains consistent with 'bail hill' smelting have recently been found close to the site, such as at Beil Brow, on the western bank of the Devil's Water, and there is documentary evidence of coppice management and 'bails' at Dukesfield in the 1550s, when a lease of Dukesfield in 1551 (*NRO Blackgate Deed B.20/1*) gave permission to smelt lead in 'bails' or bale-hills (see below, of which the following transcript is an extract):

> *This Indenture made the twentieth day of June, the fourth year of the reign of our Sovereign Lord Edward the sixth, by the grace of God King of England, France and Ireland, Defender of the Faith, and in Earth of the Church of England and Ireland the Supreme Head. Betwixt Sir John Delaval of Seaton Delaval in the county of Northumberland, knight, and John Delaval, esquire, his son and heir apparent, upon the one party; and Clement Heslop, Hugh Robinson, William Hewitson, and George Hewitson, of Allendale within the liberties of Hexhamshire upon the other party. WITNESSETH that the said Sir John Delaval and John Delaval, for and in consideration of seventy pounds of good and lawful money of England and one hogshead of wine well and truly contented paid and delivered unto the said Sir John Delaval…*

***Illus. 05**: View of Dukesfield Arches from the north-west at the outset of excavations.*

***Illus. 06**: View of Dukesfield Arches from the south at the outset of excavations.*

***Illus. 07**: View of Dukesfield Arches from the south during the excavation of trench site 2.*

***Illus. 08**: Remains of the 'New Dam' on the Devil's Water.*

***Illus. 09**: Detached barn or bothy at Dukesfield Hall formerly used to stable horses used in the transportation of lead ore from the west.*

***Illus. 10:** Iron hearth-stones in the farmyard of Dukesfield Hall - their form suggests that they may have been used to create a vent or tuyere for the bellows blast.*

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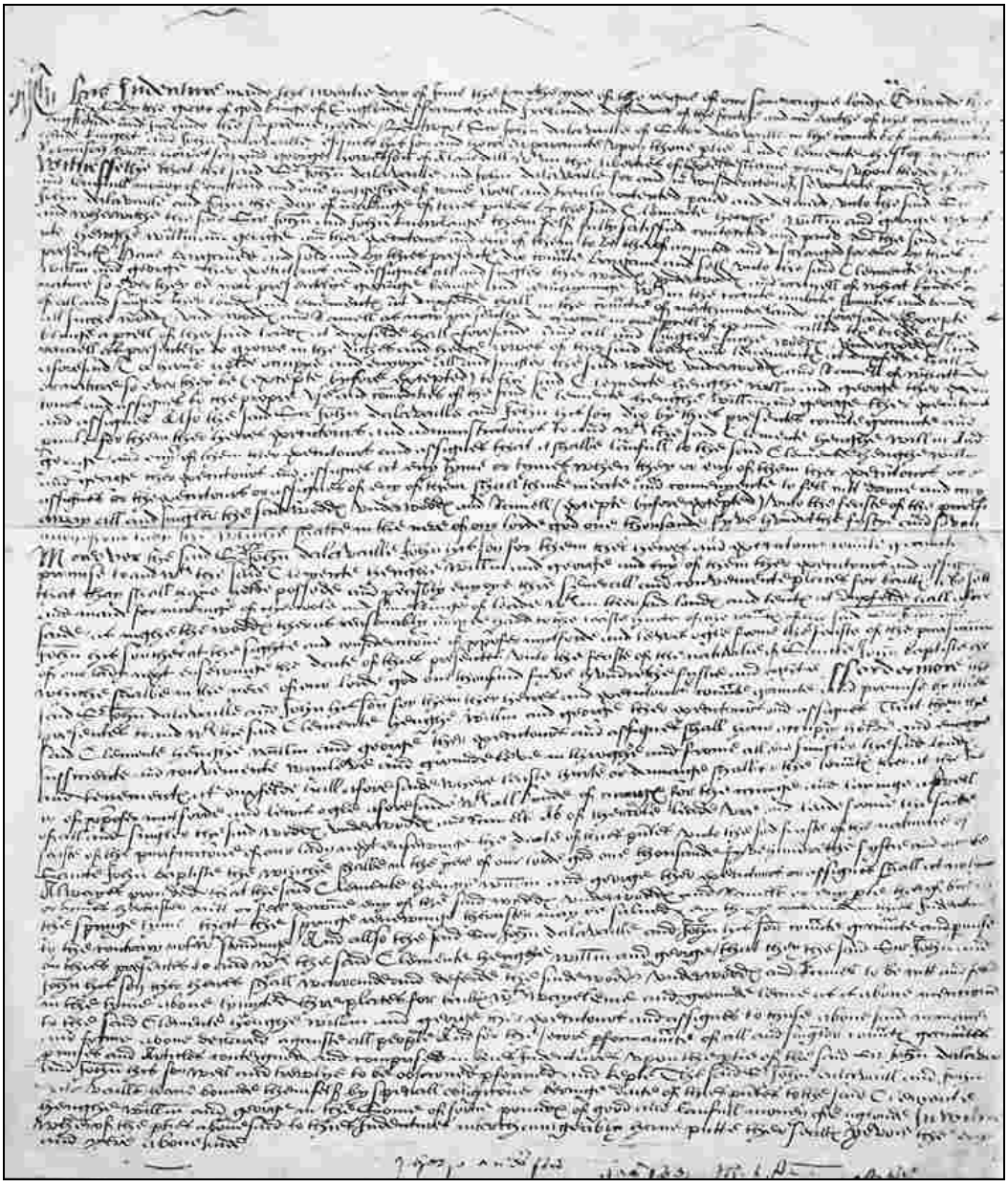
***Illus. 11:** Iron hearth-stones in the farmyard of Dukesfield Hall - one of which appears deformed by heat action.*

***Illus. 12**: Alan Biggins conducting a geophysical survey aided by site assistants and project volunteers.*

***Illus. 13**: Volunteers carrying out geophysical survey.*

…that it shall be lawful to the said Clement, Hugh, William, and George, their executors and assigns, at any time or times when they or any of them, their executors and assigns, or the executors and assigns of any of them, shall think meet or convenient to fell, cut down and carry away all and singular the said woods, underwoods, and ramel (except before excepted) unto the feast of the Purification of Our Lady, the which shall be in the year of our Lord God one thousand five hundred fifty seven. Moreover the said Sir John Delaval, John his son for them, their heirs and executors commit, grant and promise to and with the said Clement, Hugh, William, and George, and every of them, their executors and assigns, ***that they shall have, hold, possess and peaceably enjoy three several and convenient places for bails to be set and made for making of charcoal and smelting of lead within their said lands and tenements at Dukesfield Hall aforesaid****, as nigh the woods there as reasonably may be had to the least hurt of the tenants of the said Sir John and John his son…*



The Dukesfield estate, comprising several farms on the east bank of Devil's Water and the mill site, was bought in 1668 by William Blackett, who had been mining lead in the upper reaches of Weardale and the Allen dales for several years. It cannot be confirmed - as is suspected from a reference in 1687 to ore sent from mines in Blanchland - that the smelting of lead was in operation at Dukesfield prior to Blackett's purchase of the site, but the nearly Blackhall smelt mill was in operation by 1653, and by 1675 five ore hearths and a slag hearth were in operation at Dukesfield, which would have represented a dramatic increase on any previous smelting operations there. During the 18th century Dukesfield was the most important of the WB Lead Company's mills, with annual smelting fluctuating (according to the price of lead) between 500 and 1,000 tons per year from the 1720s to the late 1760s, increasing to reach around 3,000 tons by 1790, thereafter stabilising at around 3,500 tons throughout the period of the Napoleonic Wars. It is likely that the surviving arches and the graded track running southwards to Dukesfield Hall date from this period of expansion in the second half of the 18th century.

***Illus. 14**: Extract from an estate plan of 1771, showing buildings on the smelt mills site, but not the arches and chimneys.*

Dukesfield documents held in the collection of Northumberland Record Office (NRO 672 E/1/E/3) transcribed by John Gordon, suggesting that the Refinery was constructed in the second half of 1765:

To Mr Isaac Hunter jun[io]r at Dukesfield Newcas[tle] 15 March 1765

Sir I have got you a stock of Boneashes already for your Refining house, tho[ugh] I do not suppose you have yet made any preparations for building it; but I would now have you proceed with all expedition and as to the boneashes they will be at Blaydon and you can send for them when you have opportunity
I am etc Hen Richmond.

To Mr Isaac Hunter Jun[io]r at Dukesfield Newcas[tle] 2 June 1765

Sir I think it would be right to fetch as much of the Rookhope refineable Lead to Dukesfield Mill as with what you now have and can get from Allanheads Mill will make so much as to keep your refining House employed till this time 12 months- for this purpose I reckon 2000 p[iece]s from Rookhope will be sufficient: for your 2 furnaces will not refine more than 4000

p[iece]s in a year the rest you may order to Blaydon and the sooner it is done the better. For I shall lay the carriage off very early this year that we may not have so much Lead in the Way next winter as there has been the two winters past.
I am etc Hen Richmond.

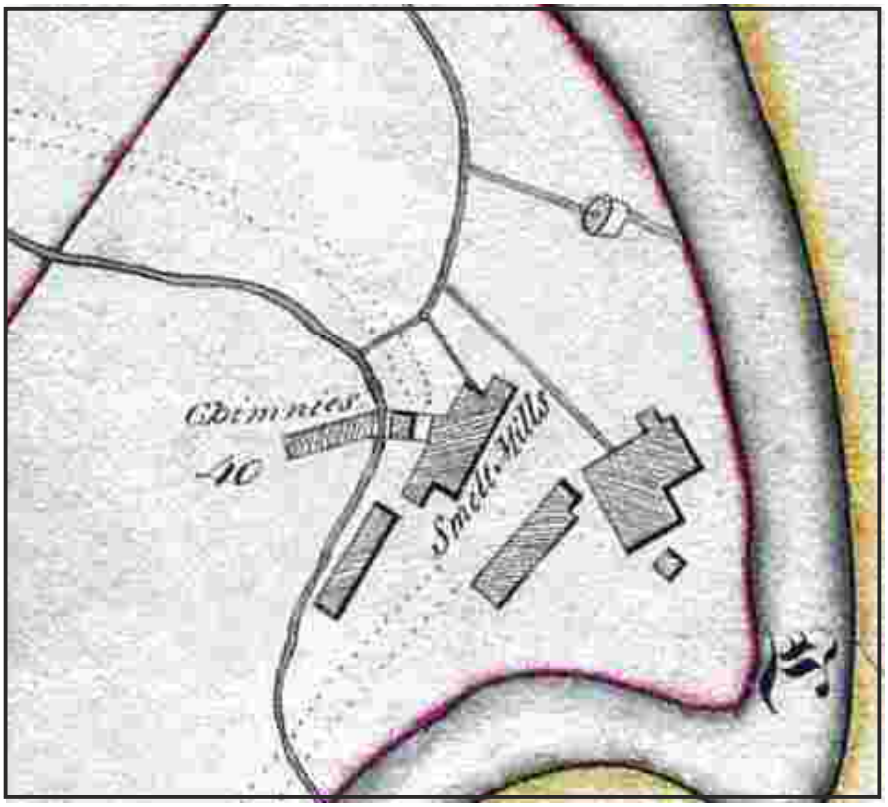
To Sir W[alte]r Blackett B[arone]t MP at Morpeth Newcastle 4 July 1765

Hon[ou]rd Sir Mr Hunter writes me that the smelting 500 Bings of S[i]r Lan[celot] Allgoods Ore at Dukesfield Mill will stop your business there for two months. He says further that there is not a bing stead but what has ore in it & that the Refining house which is now building there has left no room for Laying this ore & the slags of it distinct from your own, so that I do not see how it is possible to accommodate Sir Lance[lo]t this way. As to buying his ore, I am sure you have offered him enough for it. I find he had tried others before he offered it to you, & could not get a price to his mind.
I am Hon[ou]rd Sir Y[ou]r Faithful & Mo[st] Obed[ien]t Serv[an]t HR.

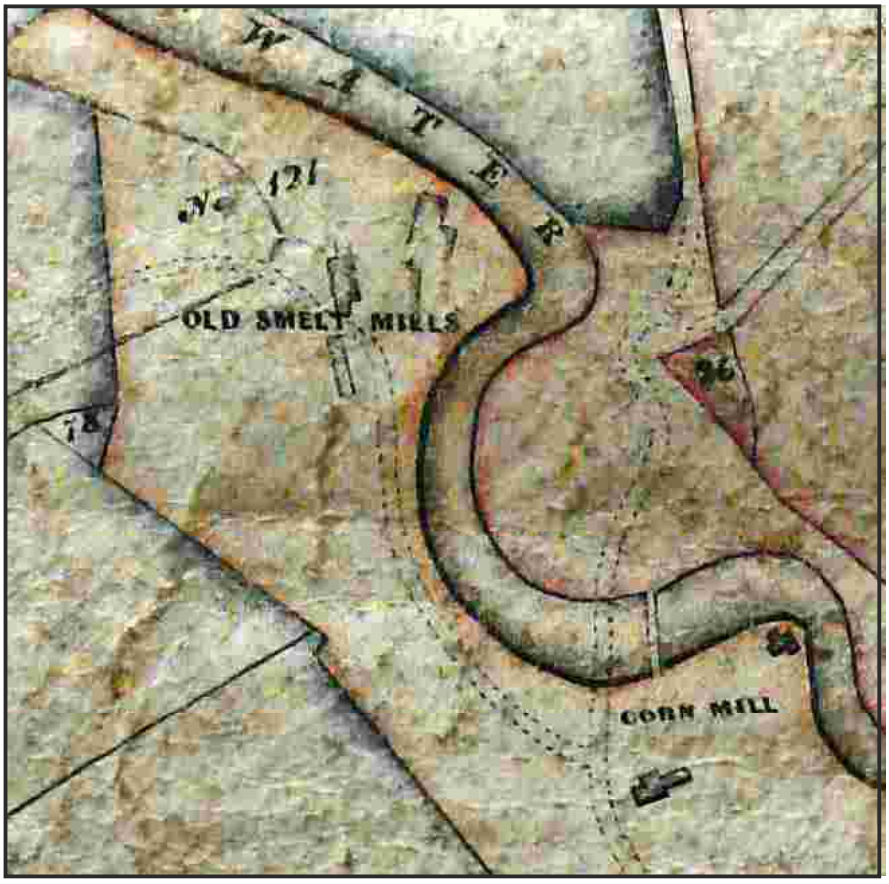
Table showing a hiatus in Dukesfield lead production in 1765, and subsequent increased productivity

		Ore rec'd Bings	Ore hearth	slag	waste	charge
1764	Jan-Mar	33	2,013	30	77	£ 148
	Apr-Jun	167	2,295	167		£ 235
	Jul-Sep	871	2,446	25		£ 418
	Oct-Dec	121	2,340	260	31	£ 464
1765	Jan-Mar	73	339	9		£ 55
	Apr-Jun	492				£ 153
	Jul-Sep	1081				£ 303
	Oct-Dec	64	2,219	41	61	£ 221
1766	Jan-Mar	29	1,628	165		£ 89
	Apr-Jun	802	1,894	162		£ 325
	Jul-Sep	1402	1,896	22		£ 442
	Oct-Dec	168	2,935	104		£ 421
1767	Jan-Mar	93	1,304	127		£ 93
	Apr-Jun	768	2,715	276		£ 431
	Jul-Sep	1619	3,166	123		£ 610
	Oct-Dec	75	3,591	140		£ 454

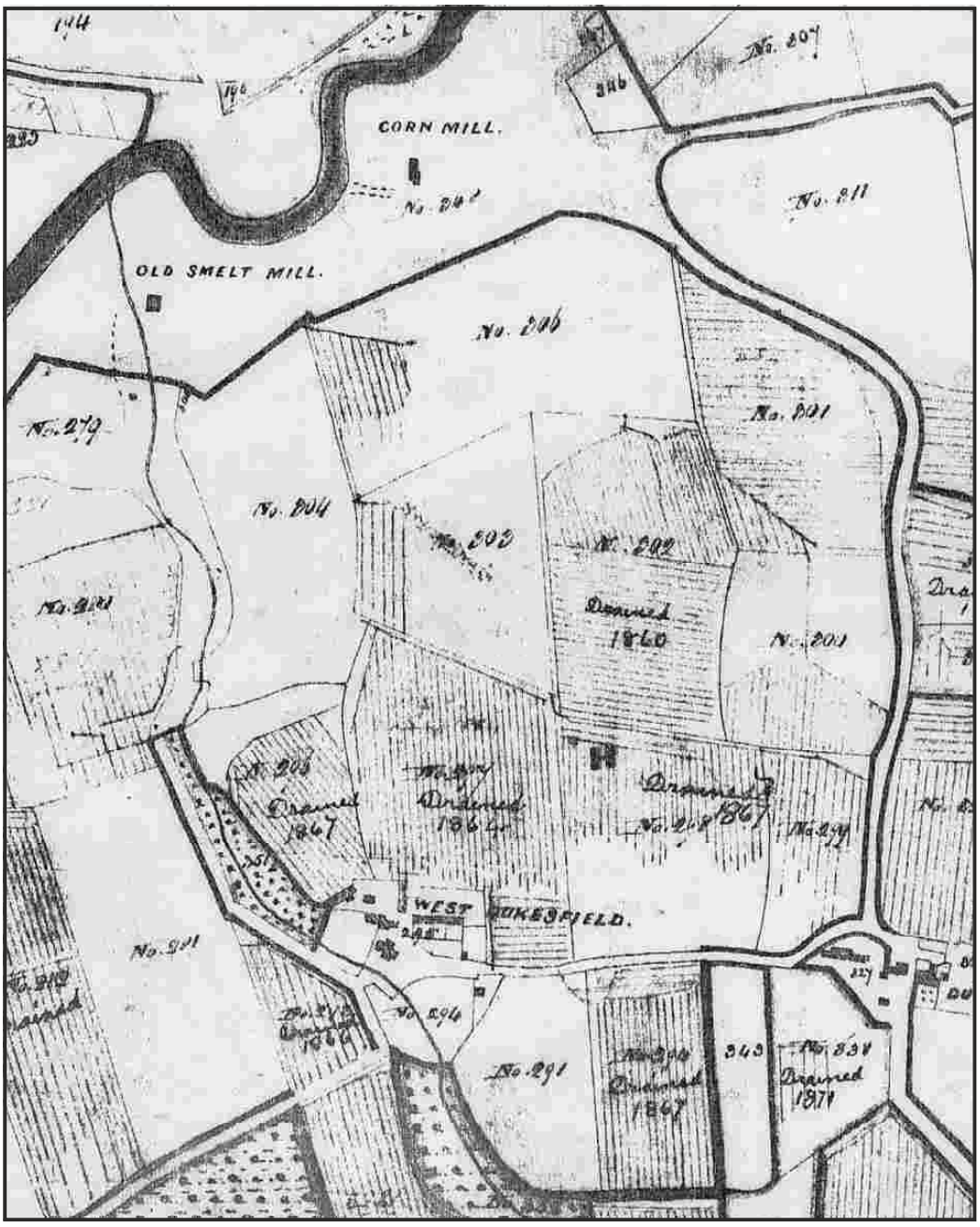
An estate map, surveyed in May 1802, shows the extent of the mill site during its heyday when it was processing some 3,000 tons of lead ore annually. The arches structure is labelled on the plan as "chimnies", with its southern arch spanning the Hall Burn, and the trackway from Dukesfield – which gave access to the lead road towards Blaydon - curving through the northern arch. The course of the mill race can be followed westwards away from the site, and a culverted spillway drops beneath the track to Dukesfield Hall, emptying into the Hall Burn.



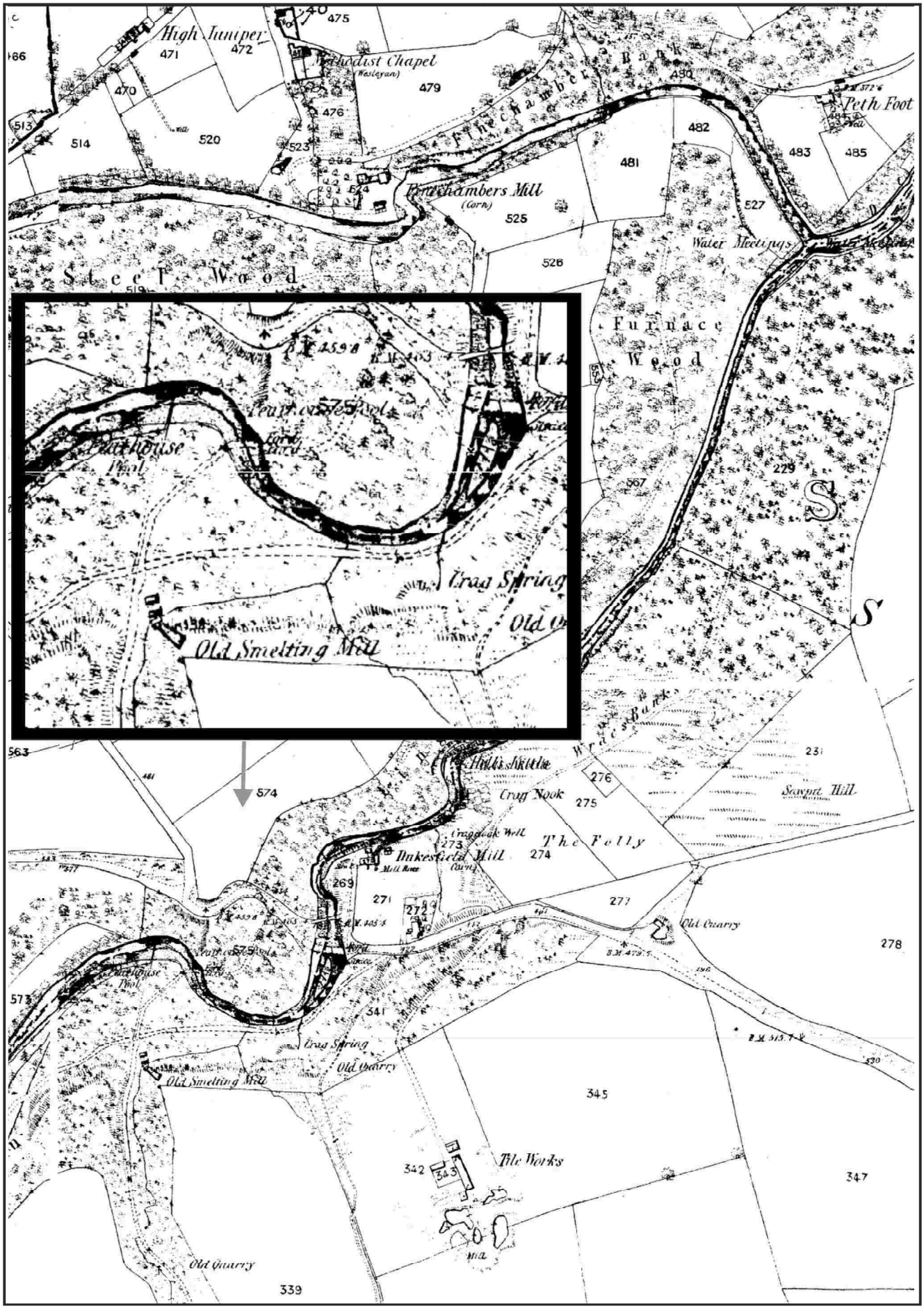
***Illus. 15**:*
A plan of the smelt mill works taken from an estate plan of 1802.



***Illus. 16**: The partly dissembled works shown on an estate plan of 1848. This plan does not appear to represent the present arches, but does show the presumed main smelt ills building north of it, with a launder approaching its west side from the leat.The plan also appears to show the remains of structures north of the main smelt mills and hints at the existence of a trackway fording the stream in the position shown on the 1st edition Ordnance Survey plan.*

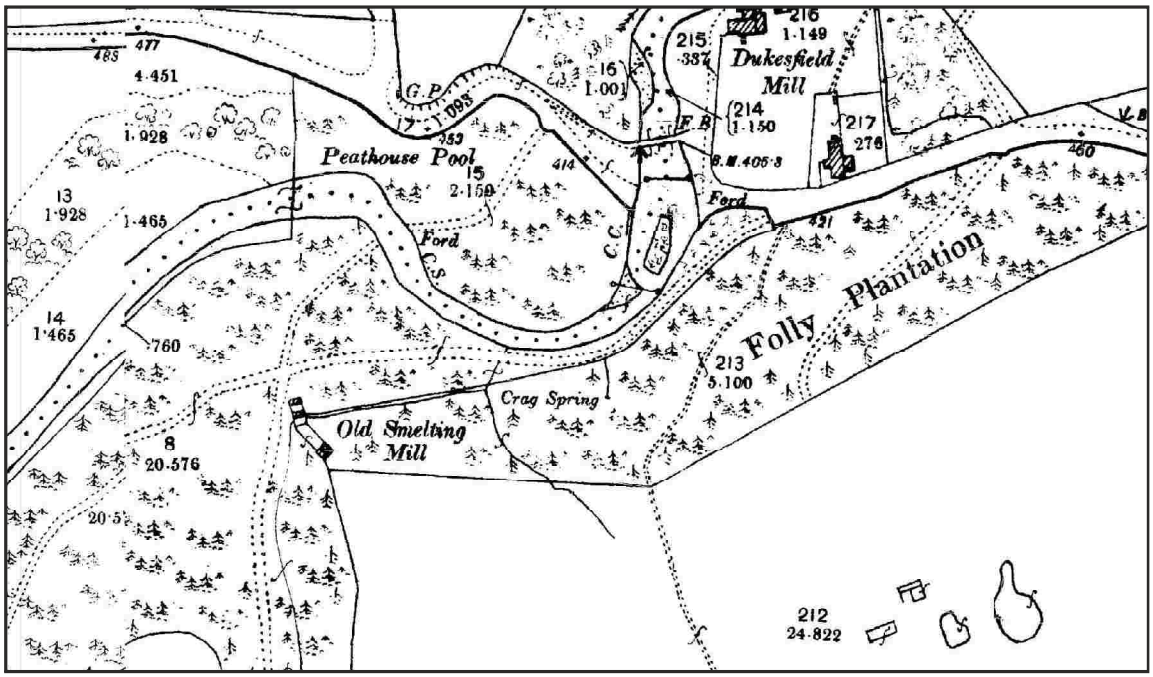


Illus. 17*: An estate plan of c.1860 showing the abandoned smelt mill site in relation to West Dukesfield. Note that the Hall burn is shown running past the site into the Devil's Water, rather than through the arches as on earlier and later maps, but this may be an aberration.*

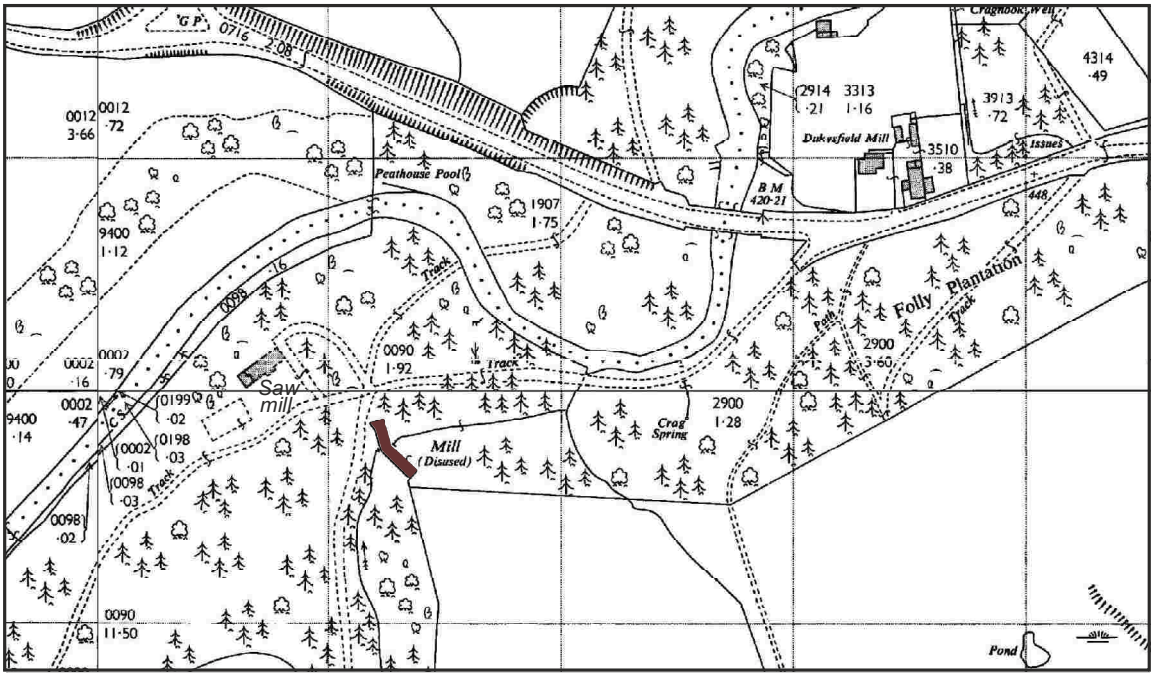


***Illus. 18**: Extract from the 1st edition Ordnance Survey Plan (1860s), showing the smelt mill site (see out-take) with Dukesfield corn mill to the north-east and a tile works to the south-east.*

Note also 'Furnace Wood' some 600 metres north-east of the site, south-west of 'Water Meetings' and south-east of 'Finechambers' corn mill.



***Illus. 19**: Extract from the 2nd edition Ordnance Survey plan (1890s) showing the Dukesfield lead smelt mill site in context.*



***Illus. 20**: Extract from a 1960s edition Ordnance Survey plan showing the Dukesfield smelt mill site in context - note saw mill north-west of the arches.*

The modern trackway to Red Lead Mill runs next to the site of a building serviced by a launder which, given the height of the adjacent mill race, presumably fed an overshot wheel which drove bellows. The 'chimnies' were probably flues drawing fumes away from ore hearths in this building. The long building to its east may have been the ore bingsteads as it lies closest to the trackway into the site from the west, while north of the track, another long building is possibly the peat store, given that the nearby bend in the river is named 'Peathouse Pool'. The large building next to it, also fed by a mill launder, probably housed the reducing furnaces and refinery added to the mill complex in the 1760s. A round structure, also water-fed, lay to the west, and was perhaps used for breaking/washing slags for resmelting at the slag hearths. The mill was described in 1821 as containing 2 roasting furnaces, 5 ore hearths, 2 slag hearths, 2 refining furnaces and 1 reducing furnace.

The somewhat terse diaries of Thomas Dixon, an ore smelter at Dukesfield in the 1830s, provide some indication of how the mill worked in its final years until closure of the bulk of the plant in 1835 (Linsley 2006), an occurrence brought about by improving methods of transportation, notably the Newcastle to Carlisle Railway, under construction at that time. Smelting ceased in 1835, but the annual accounts show that small amounts of 'washing', presumably of old slags, continued until at least 1840. An estate map of 1848 shows the dismantling of the mill buildings to be well underway and perhaps nearly complete. Later plans, including the first edition of the Ordnance Survey series published in the 1860s, show the works in their present state, with no buildings surviving other than the arches, but with the original trackways along the valley bottom and from the arches to Dukesfield Hall, still present.

The 1860s Ordnance Survey plan also shows a track north-eastwards from the crossing point of the Devil's Water and Dukesfield Hall trackways which fords the river just east of Peathouse Pool. Although absent from earlier plans, it may well be that this route was also contemporary with the leadworks. Also shown on the first Ordnance Survey plan is a tileworks established after the demise of leadworking on the raised ground south-east of the leadworks chimneys and flue arches. This was furnished with a puddle mill on its south side, as well as drying sheds and a kiln, and specialised in the production of 2 inch field drainage pipes; it had gone out of use by the end of the century, although its ponds and remains of structures were still visible then, as indicated by the second edition of the Ordnance Survey series, and some undulations in the field east of the Hall burn track still remain.

2. EVALUATION PROGRAMME

2.1 Aims

The aims of the programme of excavation were to investigate buried structural remains, including the outlines of buildings and other earthworks, to determine the character, date and phasing of those remains and determine, as far as possible, their function, extent and state of preservation. A particular aim of the project was to establish the accuracy or otherwise of existing historic plans of the site to relate any sub-surface remains to the surviving arches.

The results of the excavation and interpretation programme will then be used to inform future management of the site, including potential interpretation for the benefit of visitors. In that regard, the present report includes a brief assessment of the potential for further work, and observations regarding site management.

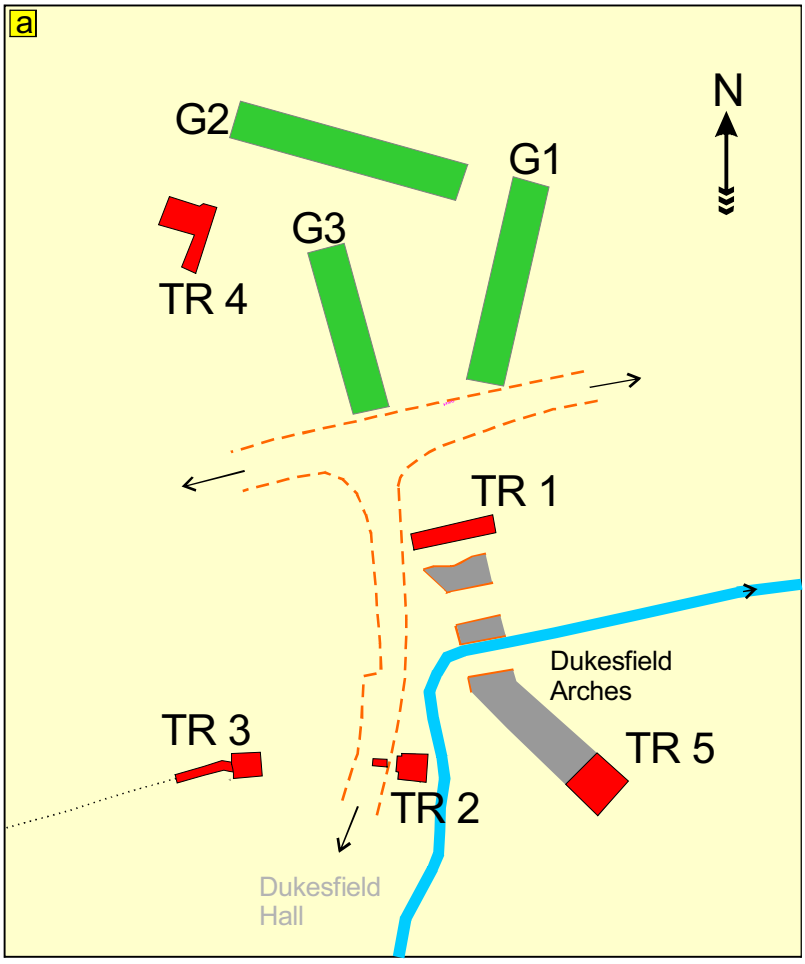
2.2 Methods

Fieldwork in October 2012 consisted of geophysical survey and the excavation of five trial trenches distributed strategically across the site, located and planned by digital survey.

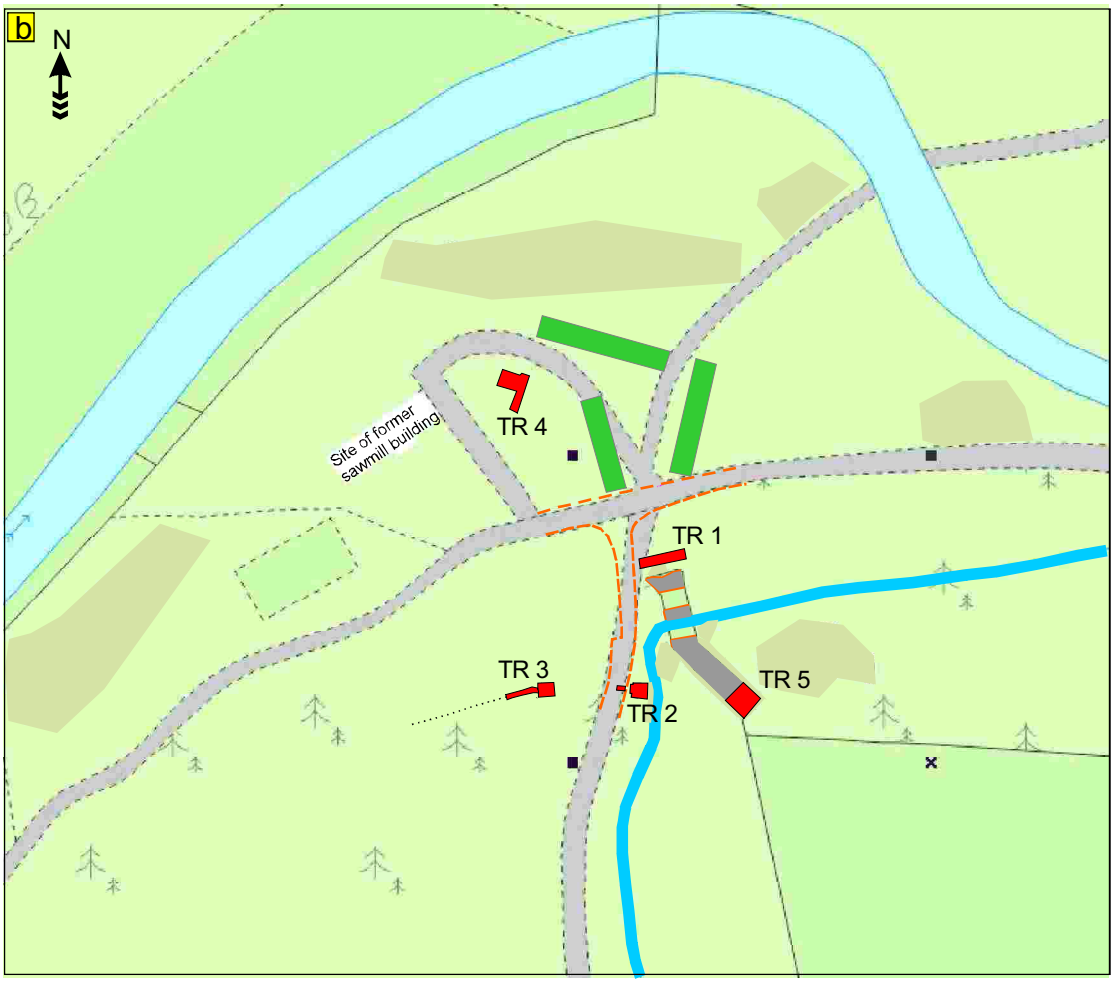
The work was carried out using core staff of the Archaeological Practice Ltd., supplemented by specialists in relevant fields - notably Peter Ryder the buildings historian, Alan Biggins the geophysical surveyor and Alan Williams who has excavated lead-works and other industrial complexes in the North-East. These were assisted by over 40 volunteers, co-ordinated by Paul Frodsham of *NP-AONB*, from *The Friends of North Pennines* and *Altogether Archaeology*, who were guided by the professional personnel and provided reciprocal specialised knowledge in a range of relevant fields.

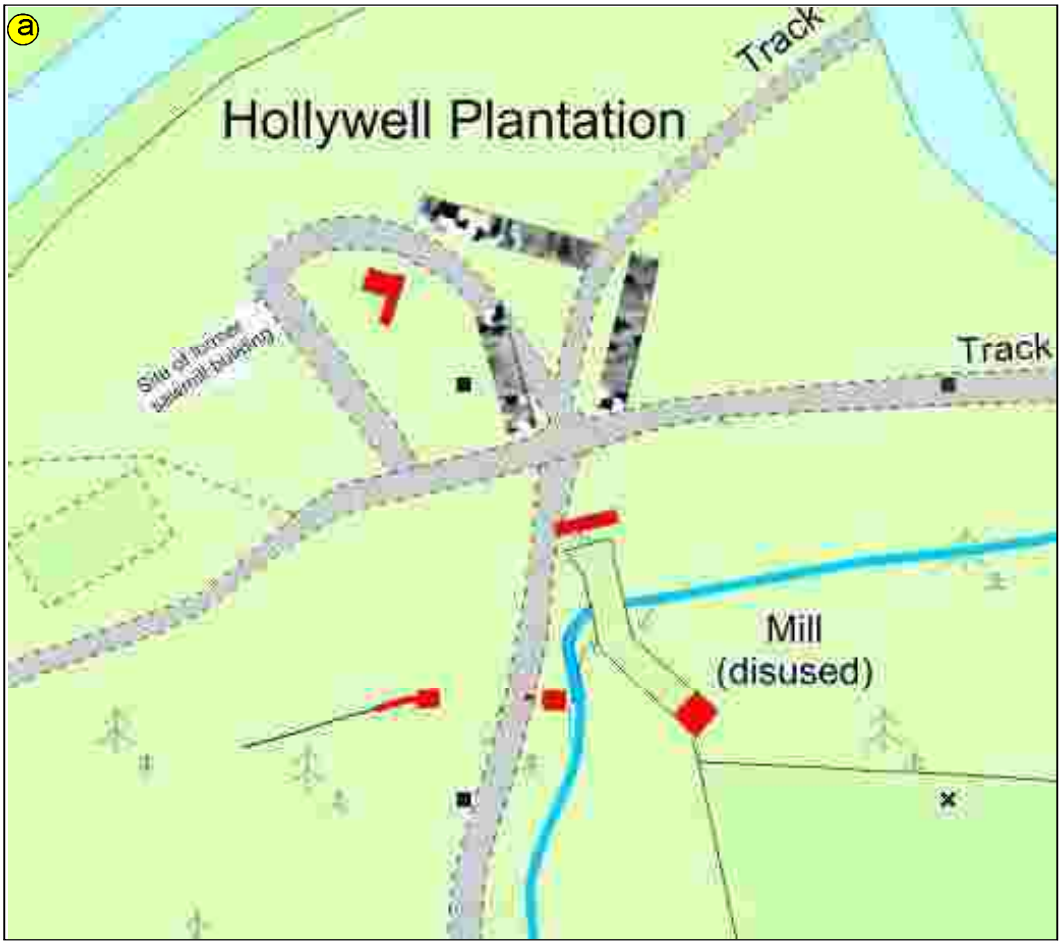
2.2.1 Geophysical Survey

Geophysical survey was undertaken on a single day, Sunday 21st October 2012, by Alan Biggins of Timescape Surveys, assisted by David Astbury, Catherine Mackey and Stephanie Jeffreys and the project volunteers, all of whom present were given the opportunity to participate in the survey. The dense ground cover of brambles and thorn bushes, together with the many large trees growing on the site, presented considerable problems to the survey team, who surmounted them by choosing three transects relatively free from trees which could be strimmed prior to geophysical survey. In order to give maximum opportunity for positive results in the testing conditions, the three areas were subjected to both magnetometry and electrical resistivity surveys, both undertaken along a series of straight transects laid out between the trees and located on the general site survey tied-in to known, mapped Ordnance Survey points using a total station. Data was downloaded on site into a laptop computer for initial processing and interim discursive analysis with the volunteers. Subsequently it was transferred to a desktop computer for further processing, plotting, interpretation and archiving (see below).

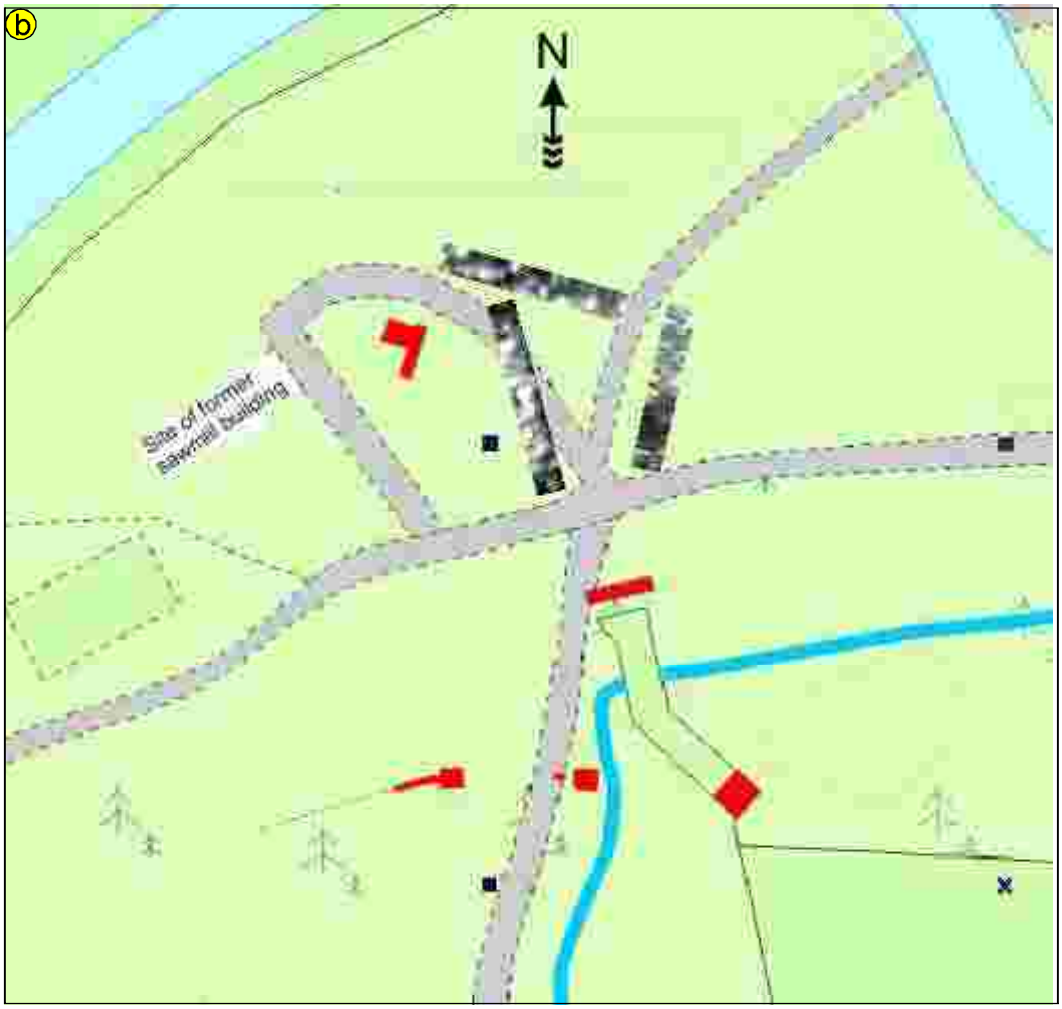


***Illus. 21** (above) **& 22** (below, on OS base): Site Survey carried out October 25th & 27th, 2012 by RC assisted by PW & MX*





Illus. 23*: The results of Magnetometry (a) and Resistivity Surveys (B) carried out at Dukesfield by Timescape Surveys, assisted by AA volunteers, in October 2012.*



2.2.2 Archaeological Excavation

The purpose of the excavation was to evaluate areas of the site and features within them using a sampling strategy, rather than full excavation. Therefore, five sites were chosen where remains could be seen as visible features, or where their presence was suspected on the basis of adjacent upstanding remains or historic map evidence. (The results of geophysics were inconclusive with regard to the survival of significant sub-surface features, so could not be used for the placement of exploratory trenches.)

Prior to excavation, all trench sites were cleared of ground vegetation and fallen branches, etc., whereupon the turf and/or mixed overburden was removed. The spoil excavated from the trenches was stored next to the excavated areas in separate piles for turf, top-soil and stones, which were subsequently back-filled by hand, or, in more accessible locations (i.e. Trenches 1, 2 & 4), with the aid of a machine provided by Mr Andrew Swallow of Dukesfield Hall, care being taken to restore the site in a way that conserved the remains as far as possible, notably by supporting the walls with loose stones.

The Trenches were excavated by hand to the top of archaeological deposits, or in some cases to the natural substrate of boulder-clay, with all trench faces subsequently cleaned and features revealed investigated and recorded as deemed appropriate. All excavated contexts were recorded in plan and section, with plans and sections drawn at appropriate scales (generally either 1:10 or 1:20). The trenches were accurately tied into the OS national grid and accurately levelled using a total station. The sparse finds from the excavations were retained and recorded by context.

3. RESULTS OF GEOPHYSICAL SURVEY

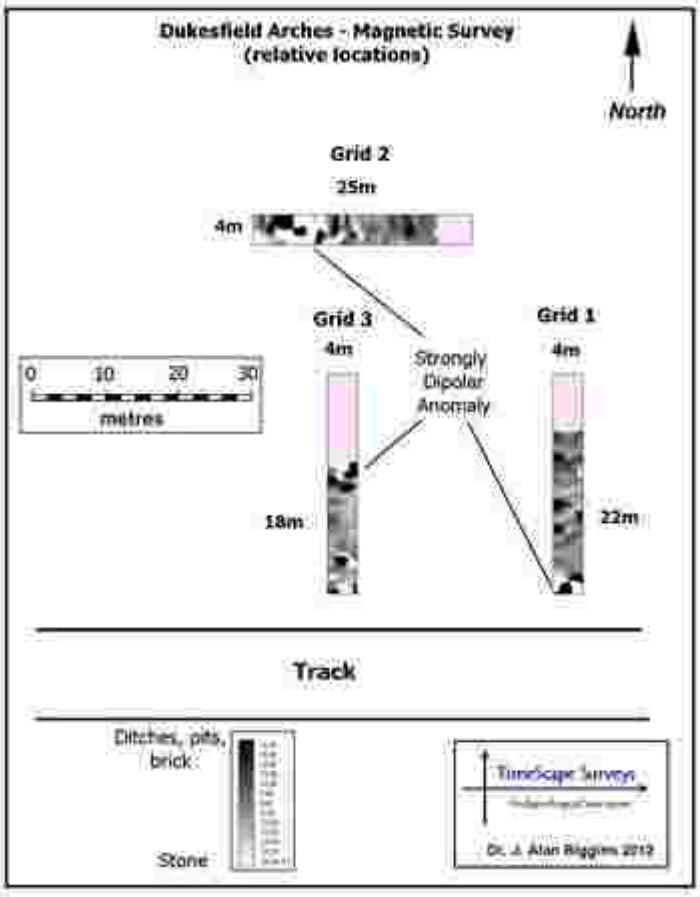
TimeScape Surveys
Archaeological Surveyors

DUKESFIELD ARCHES, GEOPHYSICAL SURVEY, 21ST OCTOBER 2012: SUMMARY OF RESULTS

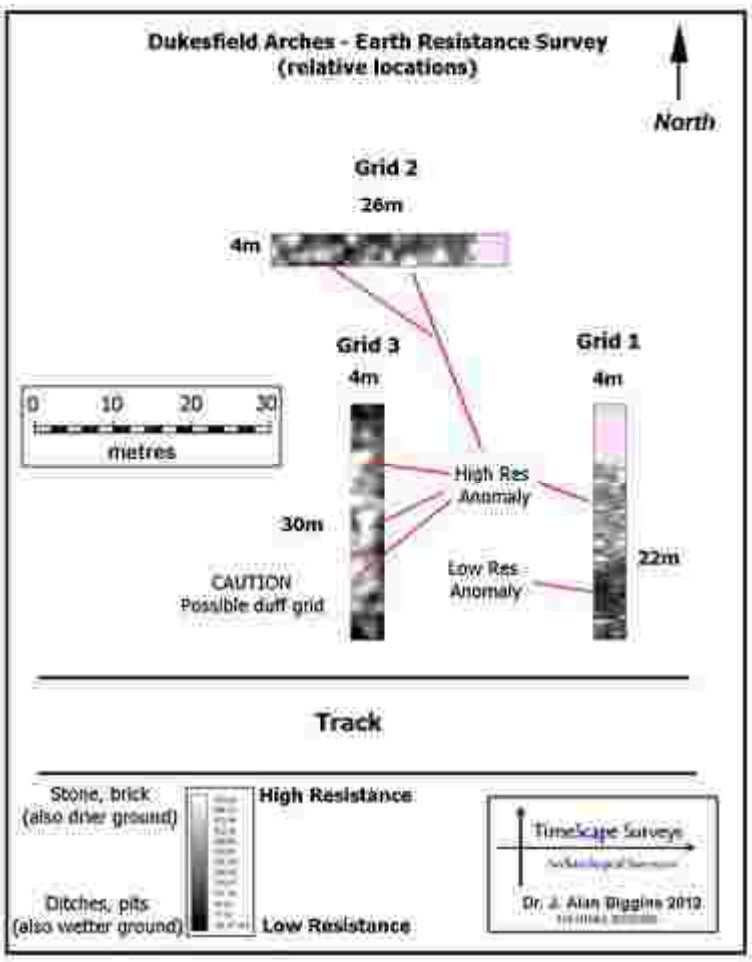
Compiled by: Dr. J. A. Biggins TD MA MSc PhD MRSC MIBiol FSA FSA Scot (Director)
With contributions by Cath Mackey BA, Stephanie Jeffries BA MA & David Astbury BA

General

The sketch plan with the results shows the relative position of the grids in relation to north and the track. The narrow with of the grids precludes full analysis.



Results of Magnetic Survey carried out at Dukesfield lead smelt mill site, 21st October 2012.



Results of Resistivity Survey carried out at Dukesfield lead smelt mill site, 21st October 2012.

Grid 1

Magnetic Survey

18m x 4m grid. A strongly dipolar anomaly was detected nearest the road. This may indicate ferrous material or possibly remains of a kiln/slag/heat fired bricks. The readings were very high exceeding the maximum response of the instrument (±2047.5 nTeslas). By comparison, buildings on Roman forts rarely exceed +20nTeslas and substantial ditches -10-12 nTeslas.

The dark areas (positive anomalies) may indicate pits, but more likely ceramic material/slag deposits

Earth Resistance Survey

22m x 4m grid. The southern sector of the grid shows a na located S of a 7m wide low resistance band which correspor feature?). The higher ground to the northern edge of the gr This corresponds to most of the more active responses from the magnetic survey.

Results of Magnetic Survey at Dukesfield, 29th October 2012.

Grid 2

Magnetic Survey

25m x 4m grid. A wide (15 x 4m) strongly dipolar anomaly was detected within the western sector of the transect. Morphological characteristics were not evident, but this may indicate the remains of a kiln/slag/heat fired bricks. A ferrous component cannot be discounted. The readings were high (+960 & - 1960nTeslas),

Earth Resistance Survey

26m x 4m grid. Two linear high resistance anomalies (7 & 10m respectively), slightly offset, are aligned almost N-S. Possible building foundations? Highly anomalous responses from the magnetic survey are located along theses features.

Grid 3

Magnetic Survey

18m x 4m grid. A strongly dipolar anomaly was detected nearest the road; this was discrete in size. A more substantial, but similar anomaly, was found on the northern edge of the transect. This may indicate ferrous material or possibly remains of a kiln/slag/heat fired bricks. The readings were high (+258 & - 45nTeslas), probably indicating a ceramic/slag origin. Ferrous material would generally give a higher response. The smaller dark areas (positive anomalies) may indicate pits, but more likely ceramic material/slag deposits

Earth Resistance Survey

30m x 4m grid. Virtually all of the central sector of the transect showed virtually contiguous high resistance anomalies. **N.B.** The data in this grid should be viewed with extreme caution.

CONCLUSIONS

The results of geophysical survey using Earth Resistance and Magnetic techniques suggest the presence of mixed sub-surface deposits but provide no clear patterning to indicate the nature of those deposits. Specifically, no clear built features, including walls or ditches can be detected within the results, nor can any of the anomalies present in the survey plots be associated with particular deposits. The nature of ground conditions on the site and the resulting small size of available transects certainly impacted upon the quality of results, and it is unlikely, given the nature of those conditions, that a survey over a significantly wider area could be attempted successfully without prior deforestation.

4. RESULTS OF EXCAVATION

3.1 *Trench 1* – 9m (length) x 2m (width)

Description (*Illus. 24-31*)

Trench 1, positioned north of the surviving arches in an area of mature trees and some scrub vegetation - the latter cleared before commencement of excavation was sited to investigate the presumed site of the ore hearths shown on historic maps of the site. Although initially proposed as an L-shaped trench extending along the north dace of the arches, with an extension at right angles from the east end, in the event the extension was not made due to the depth of deposits found in the original trench.

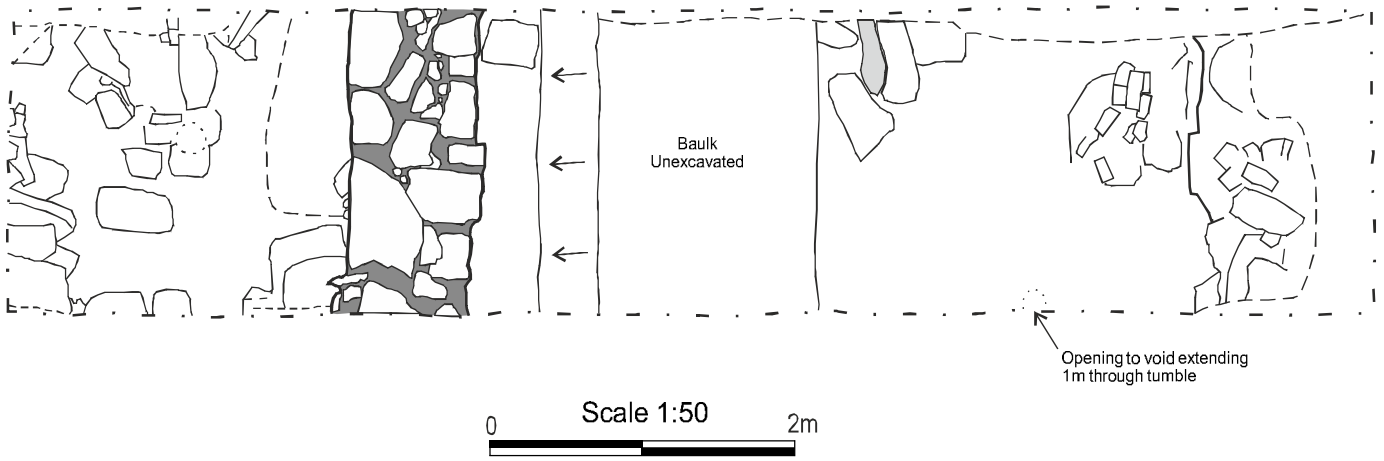
The removal of turf and loose overburden from the trench revealed a mixed deposit of sandy loam with abundant mortar and some rubble, extending throughout the trench. It was determined to excavate test pits at the east and west ends in order to investigate the nature and depth of likely deposits. The test-pit excavated at the west end encountered a dense rubble spread, comprising brick and worked stone along with mortar, dipping eastwards from the west end of the trench. This was investigated closely for evidence of structural integrity, but none was found, suggesting that the deposit was a result of tumble or demolition. Further investigation revealed that the depth of this deposit is considerable – a small void encountered at a depth of 0.7 metres on the northern edge of the trench some 1.5 metres from its west end could be penetrated with a measuring pole to a depth of more than an additional metre. At this point the excavation of the west end of trench 1 was abandoned.

Excavation continued in the east part of the trench, separated from the west part by an unexcavated baulk. Here, a further rubble deposit was encountered within a matrix of sandy-loam and mortar fragments, becoming more concentrated with depth at the east end of the trench. Further west, close to the unexcavated baulk, the remains of a substantial, well-constructed stone-built wall, 0.92 metres wide, was encountered at a depth of 0.65 metres and traced to a depth of 1.20 metres, whereupon the excavation was abandoned.

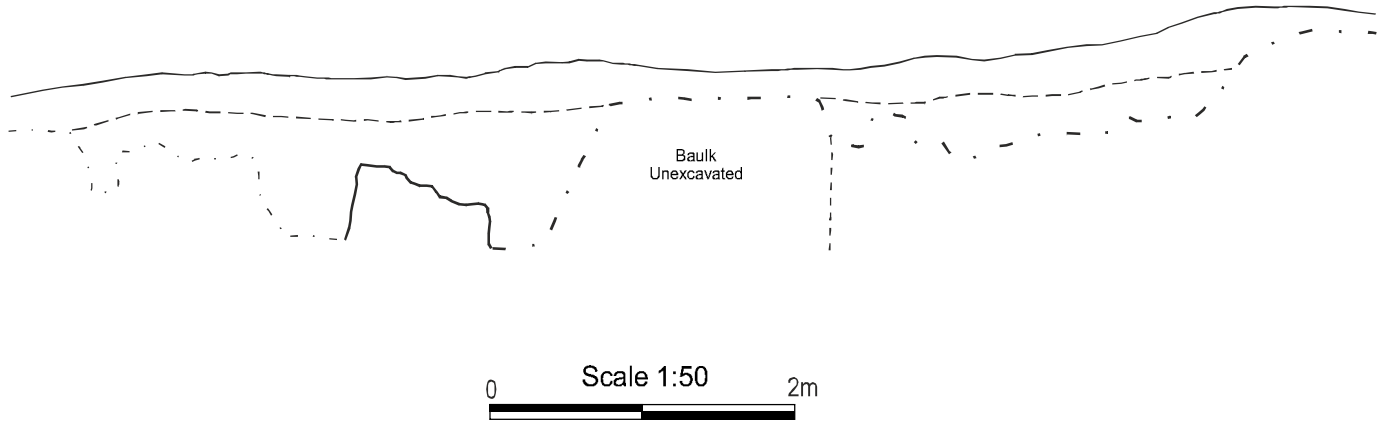
Interpretation

The rubble deposits encountered in trench 1 contained both stone and brick fragments, the latter apparently of the same material and dimensions as those currently lining the surviving arches, including the fragmentary remains of a corbelled construction forming the northern edge of the current arches. It is difficult to avoid the conclusion that the rubble deposits found in Trench 1 derive from part of the same structure, which presumably formed part of the support carrying a flue (or flues) from the smelt mill to the chimneys.

The wall found at a depth of 0.65, continuing to at least 1.2 metres below current ground level (bgl), is wide enough to suggest that it once formed part of a substantial building. Its orientation, however, does not seem to tie in well to the known historic plans of the site, which show a building, or perhaps two overlapping buildings, orientated east-west and abutting the north side of the arches. The position of the wall uncovered in Trench 1 suggests that it must either have been an internal division of the structure(s) seen on historic plans, or, perhaps more likely, the remains of an earlier phase of building on the site. It might



Illus. 24: *Plan of Trench 1, Dukesfield Arches.*



Illus. 25: *North Facing Section of Trench 1, Dukesfield Arches.*

***Illus. 26**: The position of Trench 1 on the north side of the arches*

***Illus. 27**: Volunteers inspecting Trench 1 at an early stage in the excavations.*

***Illus. 28**: View from the east end of trench 1 at the end of the excavation period.*

***Illus. 29**: View from the north of wall remains exposed in Trench 1.*

***Illus. 30**: View of the west end of Trench 1.*

***Illus. 31**: Close-up view of rubble at the west end of Trench 1.*

be suggested that an earlier phase of industrial activity may have relied, at least initially, on the Hal burn as a source of power, in which case key buildings are more likely to have been arranged parallel to its original course (i.e. before it was diverted through the late-18th century arches). Whether the building remains uncovered in Trench 1 fit with this explanation could only be tested by further excavation to examine its structural relationship with the arches, which it would be expected to underlie if belonging to an earlier phase.

Several small sherds of domestic pottery were found alongside some pieces of ironwork, sparse pieces of slag and brick fragments, but as all were recovered form mixed deposits, none shed any light upon the phasing of the structural remains or activities carried out therein.

3.2 *Trench 2* – 7m (length) x 3m (width)

Description (*Illus. 32-39*)

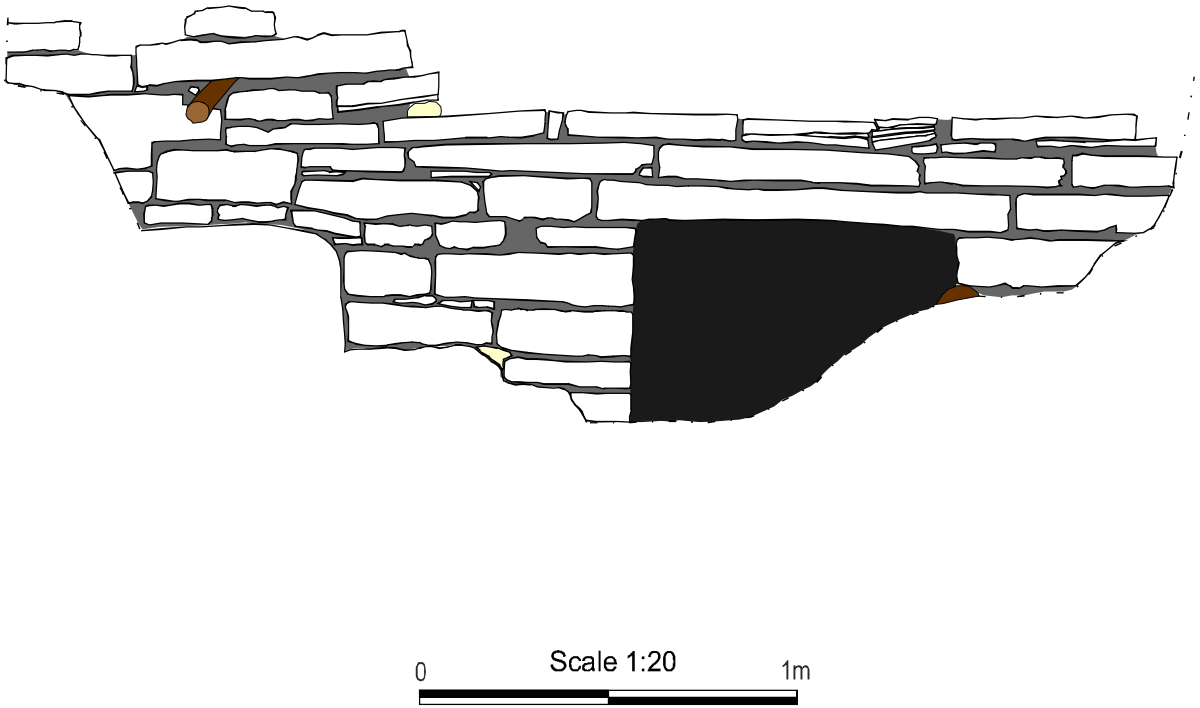
Trench 2 was positioned on and adjacent to the Dukesfield Hall access track where, prior to excavation, built stonework was visible on the surface where it crosses the culverted leat. The east end of the culvert where it opens onto the Hall burn was also just visible prior to excavation as a squared opening in a stone-faced wall.

The excavation required in order to expose the culvert top and opening amounted to the clearing away of unstratified overburden using hand tools, within a delineated area. This process revealed, in the middle of the trackway, a series of linear stones arranged east-west, forming the top of the culvert. Closer to the east side of the trackway and Hall burn the arrangement of stones was less well-defined, and it appeared that at least one stone had fallen out of the structure, although inspection of the culvert through its entrance indicated that the roof of this end part of the structure was supported by a large slab or flag below the surface stonework. The end of the culvert was formed by a well-coursed drystone wall within which a squared channel for the passage of the leat was created using a roughly dressed stone lintel, above which were two further courses of surviving stonework (originally probably more). The wall forming the end of the culvert respected a large boulder which had been shaped to fit within the body of the wall upstream of the culvert opening, and appeared to be continuous with a burnside wall visible on the west bank of the stream to the north. No significant features were found on the streamside east of the culvert opening, where excavation was made difficult by tree roots and waterlogged conditions. However, it did appear from the arrangement of large stones and boulders there that an attempt had been made at some stage to channel the outflow of water from the leat into the stream. No artifactual or ecofactual finds of any description were recovered from Trench 2.

Interpretation

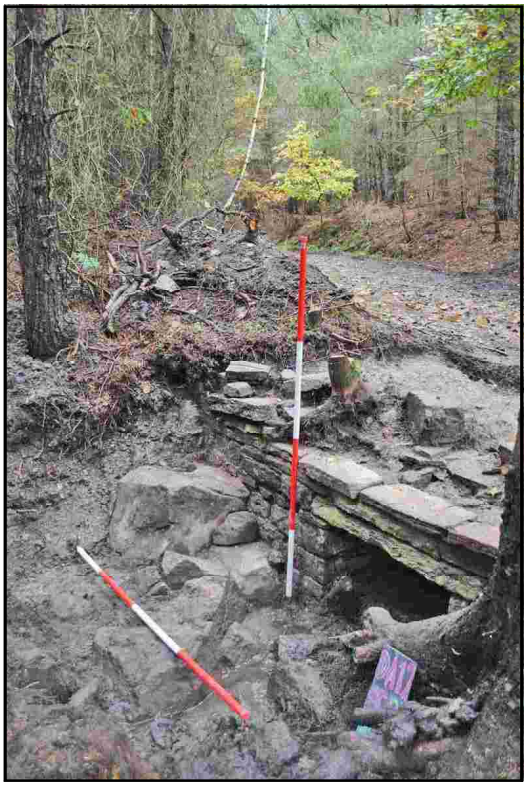
The stonework remains exposed in Trench are those of the top of the culvert roof as it runs under the trackway to Dukesfield Hall, and its eastern entrance which allows the outflow of the leat into the Hall burn. It appears from its form of construction and disruption to the culvert top that the present outflow opening is not original, but has been replaced at some stage, possibly when the wall (with which it appears contiguous) forming the west side of the Hall burn as it enters the arches was built. The disruption to the pattern of stonework forming the top of the culvert in the middle of the trackway which is apparent towards its west end may be explained by the removal of an existing arched entrance – perhaps similar in

Illus. 32: *Plan of Trench 2, Dukesfield Arches.*

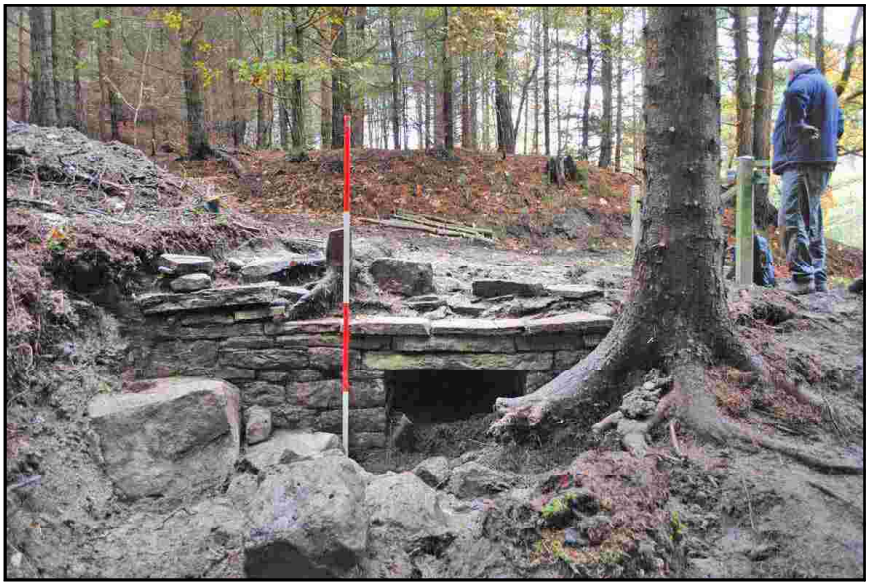


Illus. 33: *East facing section of Culvert exit revealed in Trench 2, Dukesfield Arches*

***Illus. 34**: View looking north-west towards culvert entrance to the Hall burn in Trench 2.*



***Illus. 35**: View looking south-east towards culvert entrance exposed in Trench 2.*



***Illus. 36**: View of the east-facing culvert entrance exposed in Trench 2.*

Illus. 37*: View looking south along the upper part of the culvert entrance exposed in Trench 2.*

Illus. 38*: View looking east over the Dukesfield Hall access trackway, along the exposed roof of the culverted leat.*

Illus. 39*: View northwards of an exposed section of culvert roof exposed in Trench 2 (see above).*

appearance to that forming the western entrance to the leat – and replacement by the present structure. The date of this putative occurrence, however, is unknown.

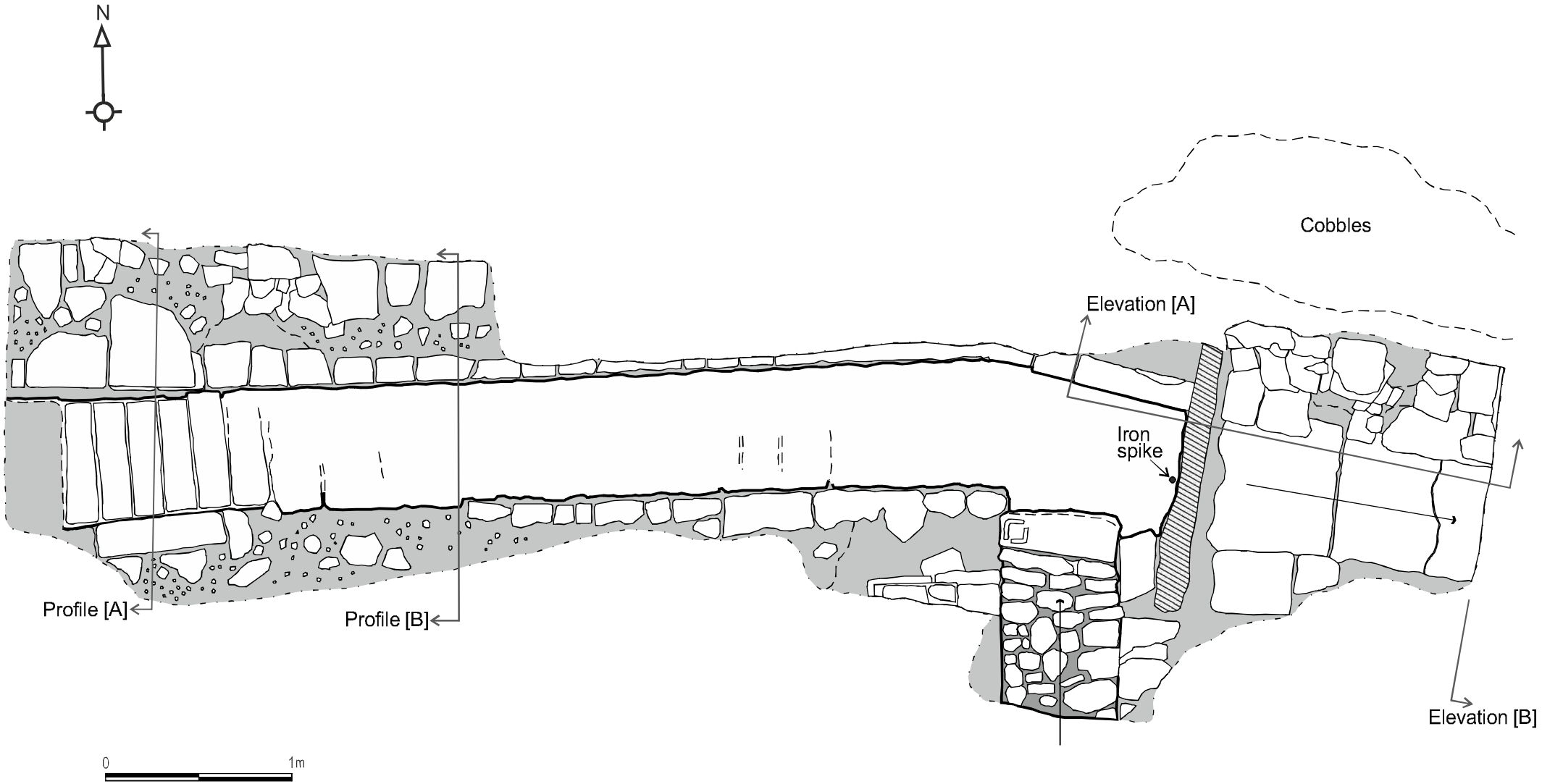
3.3 *Trench 3* – 8m (length) x 2m (width)

Description (*Illus. 40-59*)

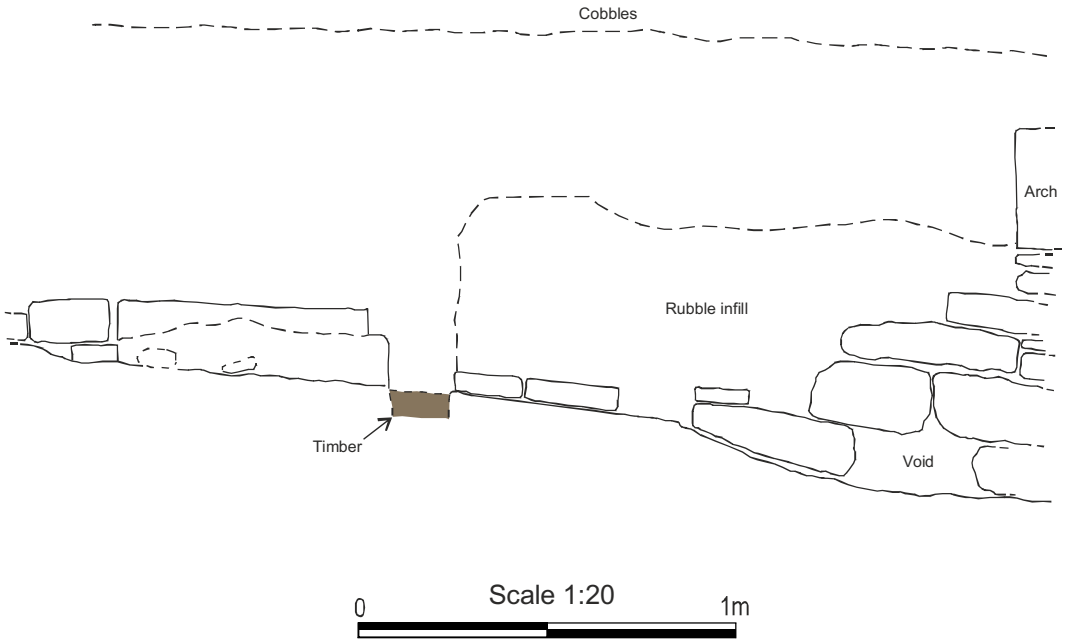
Trench 3 was excavated on the side of the northern valley side of the Devil's Water at a point some 25 metres west of its interruption by the west side of the valley of the Hall burn. Prior to excavation the course of the mill leat along the raised valley side of the Devil's Water was visible for most of its course from the 'New Dam' half a mile upstream, along with both stone-built ends of the culvert through which it flowed under the trackway to Dukesfield and into the Hall burn. Cuts in the bank on the north side of the leat just before it enters the culvert suggested the possible locations of the sluice gates which regulated the flow of water down the lauders to the mill buildings.

The excavation of the leat visible as an earthwork feature was carried out by teams of volunteers working three sections - the east end, centre and west end of the trench - as well as on the culvert top and around the upper parts of the leat towards its east end. The process of excavation involved the removal of unstratified overburden, principally leaf mould and inwashed silt. The leat was excavated from the arched culvert entrance westwards to a point where a depression in the north bank appeared to suggest a cut for one of several launders seen running off it on an early 19th century plan. Excavation in this area revealed no irrefutable evidence for such a cut, although a dressed stone incorporating a cut socket was recovered from the leat floor at the extreme west end of the trench, suggesting the likely presence of a sluice there. The leat was found to be constructed from a lining of iron hearthstones placed across the channel to form its floor and set vertically to form the lower walls on the north side; the latter, projecting only a few centimetres above floor level, had apparently been set vertically, although since all the individual pieces had fused together by rusting, it was not possible to dislodge any to confirm their depth. On the north side of the trench at the west end, a single course of dressed stones sat on the low walls formed of hearth stones, while north of this was a roughly constructed stone wall or embankment. On the south side of the leat for the majority of its excavated length there was no evidence for a raised south wall of hearth stones, although in places hearth stones set parallel to the course of the leat were in evidence at or below the level of the floor of hearth stones arranged in a single row at right angles to it, and probably served as a base upon which a stone-built south wall or leat lining was formed. In places some rough flat stones may have been residual base of such a feature. There was no clear evidence for a wall or bank outside this putative, robbed-out southern leat lining, and such a construction would probably not have been required there due to the steep natural slope on that side which would have effectively retained the south side of the channel.

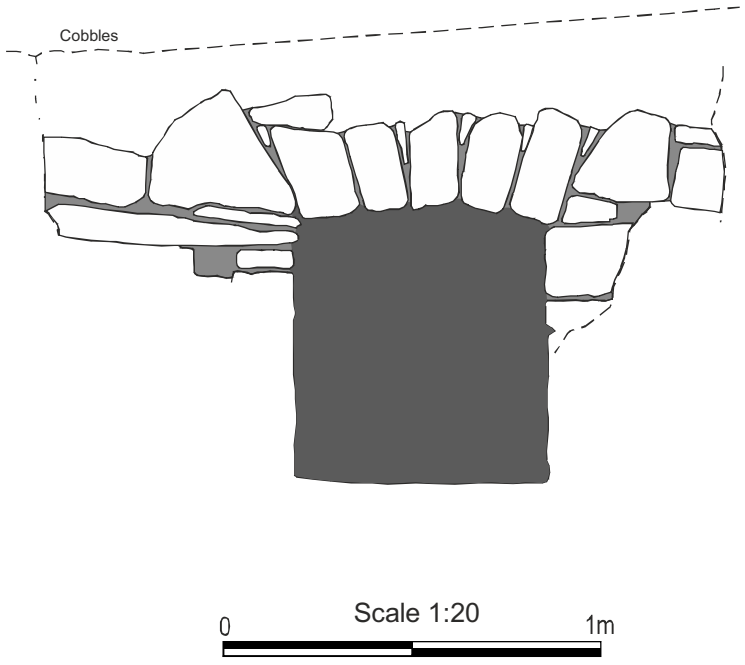
The leat ran eastwards from the western extent of excavation for some five metres before changing course slightly, but distinctly south-eastwards, by a factor of some 10 degrees, thereafter running another 1 meter to the culvert entrance. At and around the point at which the leat changed course a number of features were apparent. Most notably, extending southwards from the south side of the leat was a ramp-like feature, some 0.60 metres wide, constructed of sandstone cobbles, which ascended away from the leat floor at an angle of about 30 degrees. This feature was bounded on either side by roughly dressed stones



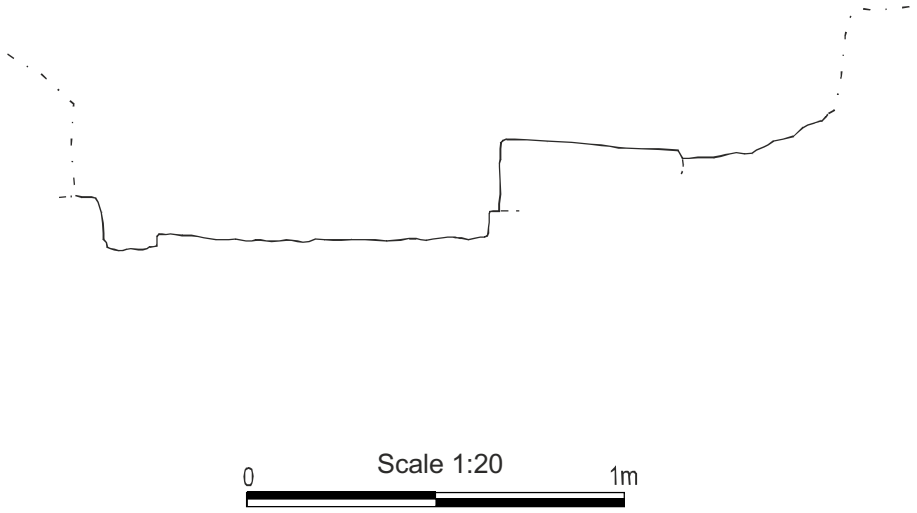
Illus. 40: *Plan of the course of the leat excavated in trench 3 at Dukesfield Arches.*



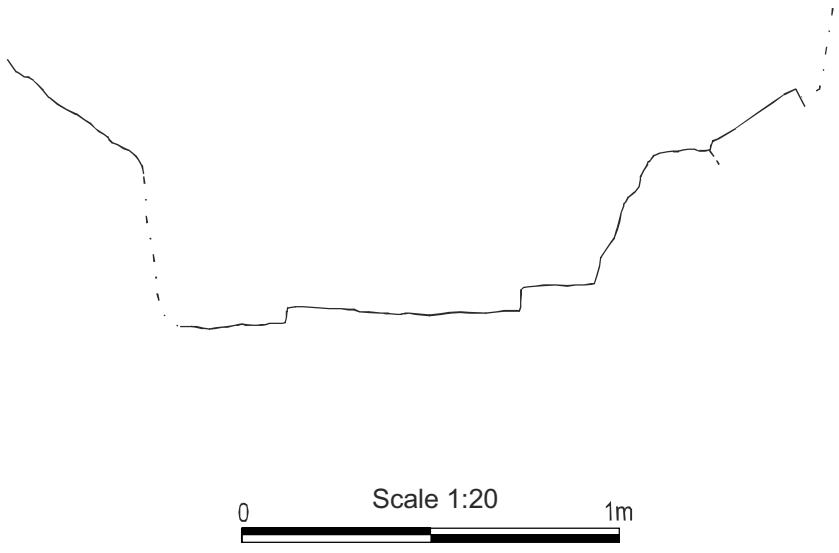
Illus. 41: *Elevation [A] Trench 3, Dukesfield Arches, Northumberland.*



Illus. 42: *Elevation [B] Trench 3, Dukesfield Arches, Northumberland.*



Illus. 43: *Leat profile [A] in Trench 3, Dukesfield Arches.*



Illus. 44: *Leat profile [B] in Trench 3, Dukesfield Arches.*

Illus. 45*: View looking west along Trench 3 during excavations.*

Illus. 46*: View looking west along Trench 3 after excavation.*

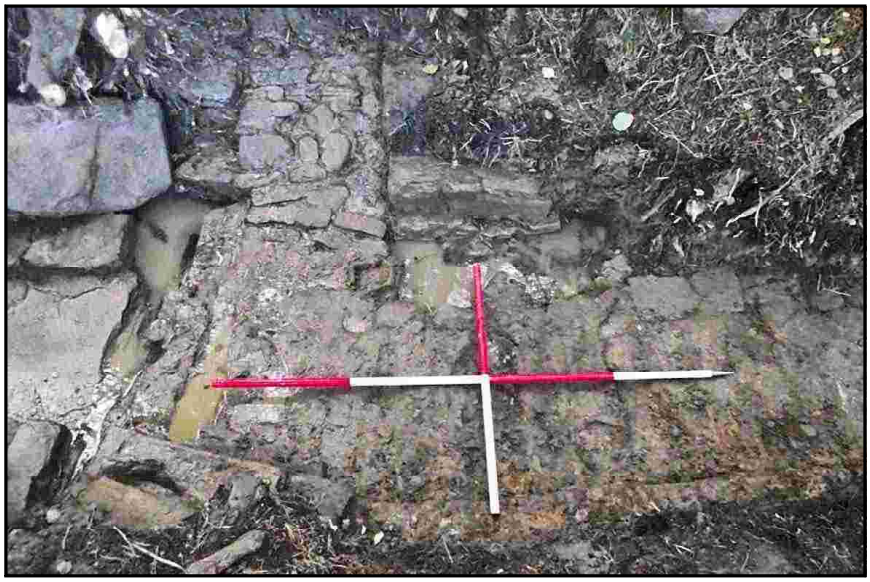
Illus. 47*: View looking east at face of culvert in Trench 3.*

***Illus. 48**: The leat floor lined with hearth stones in Trench 3.*

***Illus. 49**: Socketed stone recovered from the west end of Trench 3.*

***Illus. 50**: The west end of Trench 3 viewed from the west.*

***Illus. 51**: 'Ramp' and associated features at the east end of Trench 3, viewed from the north side.*



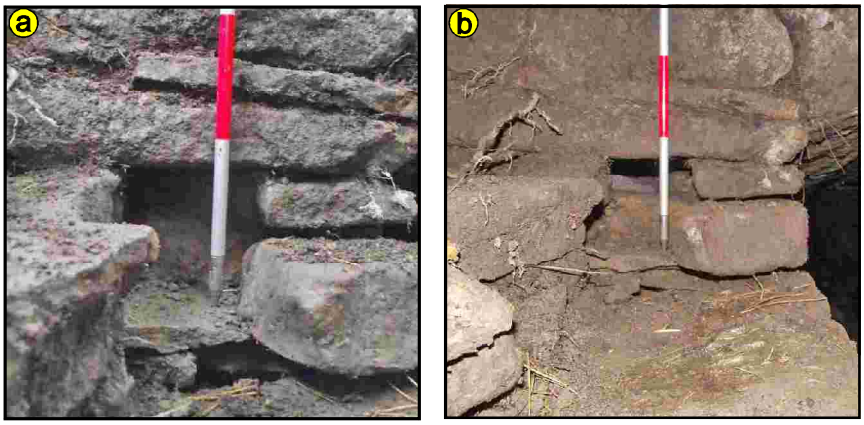
Illus. 52*: East end of the hearthstone-lined leat revealed in Trench 3, with 'ramp' to the south and flagging to the east.*

Illus. 53*: Vertical view of flag-floored culvert entrance at the east end of Trench 3, with wood-lined slot between flagged- and hearthstone-lined sections of floor.*

Illus. 54*: Detail of preserved timber and iron fittings in socket marking the position of a former sluice gate at the east end of Trench 3.*

Illus. 55*: View from the north of a cobbled feature - presumably a former water-course or access ramp - running into the south side of the leat exposed in Trench 3.*

Illus. 56*: View looking east towards arched culvert opening after the removal of a large stone slab from the floor (seen to side).*



Illus. 57 a&b*: Detailed views of a socket in the south side of the west- facing face of the culvert opening exposed in Trench 3.*

Illus. 58*: View looking east along the interior of the culverted leat from the east end of Trench 3.*

Illus. 59*: View of a deep socket in the south-facing interior wall of the culvert, just above floor level, close to its west end, as revealed in Trench 3.*

projecting slightly above its surface, therefore possibly representing the sides of a subsidiary channel. At the foot of this 'ramp' feature, in a position just south of the channel of the leat but on the western edge of the projected course of a channel descending from the 'ramp, was a square metal collar set upon or within the flat area between ramp and leat channel. It was unclear whether this artefact was in situ, since part of it became detached during excavation, but its position suggests that it could have formed a post setting associated with the ramp feature. Opposite the ramp feature and bordering the south side of the channel was a single hearthstone, its upper surface featuring a deep slot, marking the point at which the channel changes course to the south-east. This is also the point at which a channel or launder is shown descending from the leat on the 1802 plan, but no such feature could be discerned. The leat channel up to and including the section between this raised hearthstone and the 'ramp' feature was constructed of fused hearth-stones, but this was disrupted east of a line extending northwards across the channel from the east side of the 'ramp' feature. Flooding in this area prevented a clear sight of the features present, which included the remains of metalwork set in the channel floor and bounded on the east side by a distinct slot containing the remains of a wooden beam, itself apparently grooved across the width of the channel and probably represents the remains of sluice-gate apperata. Possible post-holes at either end of this feature could not be investigated satisfactorily due to flooding. Below (east of) this feature, the leat channel was formed from stone flags which continued into the culverted section. A large stone found - initially within deep deposits of silt - occupying the floor of the leat in this area (i.e. between culvert and 'ramp' feature) was initially thought to be significant, but upon removal appeared to be a secondary incursion, although could potentially have been used to block the culvert entrance at a late stage in its history.

The section of leat with flagged floor east of the 'ramp' feature was bounded on either side by a lining of stonework, backed on the north side by a bank or dry-stone wall of similar construction to that noted at the west end of the trench. The stone lining tied in with the west-facing stonework of the arched entrance to the culvert, a straight-sided channel of coursed sandstone masonry, with corbelled roof set on a springer-course. On the north side of the culvert entrance, within the west-facing supporting wall of the springer-course, was a slot some 0.12 metres long and 0.08 metres high, with a depth of c0.10 metres. A second, larger and deeper slot, measuring some 0.30m long by 0.16 metres deep and at least 0.40 metres deep was observed in the south-facing wall of the culvert close to its entrance, just above floor level.

The area above the culvert entrance was cleared of vegetation and topsoil to reveal a compacted deposit of sandy silt with abundant stone fragments, apparently deliberately liad upon the stonework of the culvert roof. An area of neat cobbling extended from the north side of the culvert roof westwards along the side of the leat channel to a point beyond the angle formed by a turn in the leat channel - i.e. beyond the raised hearthstone adjacent to the ramp feature on the south side of the leat channel, which is the point at which a launder is shown descending form the leat channel on historic plans.

Other than worked stone, hearthstones and other corroded fragments of ironwork and the decaying waterlogged wooden beam found within a slot towards the east end of the trench floor and left in situ, no artifactual or ecofactual finds of significance to the interpretation of excavated features were recovered from Trench 3 .

Interpretation

The excavation of Trench 3 revealed surviving elements of the leat channel and culvert entrance. The greater part of the exposed leat channel and part of its sides were formed from fused hearthstones. It is presumed that these were derived from the smelt mills and represent, therefore, secondary use of items discarded during the regular rebuilding of the hearths. It is not clear, however, why they should have been discarded whilst intact, nor why they were not of more value as scrap metal than as flooring material. It is known, though, that hearthstones were used for a similar purpose in the floor of the Hall burn at Dukesfield Hall farm and between the farm and smelt mills site, as well as in the New Dam on the Devil's Water. The use of discarded hearthstones implies that this represented a relining of the leat, since the quantities of material available would only have accrued after some considerable period of industrial operation. It seems likely that the channel of the leat was originally lined with along north and south sides as well as the floor, but whether hearthstones or dressed sandstone blocks were used for this is unknown; the latter seems more plausible, since some blocks remain, but in either case it seems that robbing has removed most of the evidence. The presence of a launder controlled by sluice-gate is suggested at the west end of the excavated section by a cut in the north bank of the leat channel and discovery there of a socketed stone capable of holding a substantial wooden post. The presence of a second launder, also controlled by sluice-gate, indicated on historic plans closer to the culvert entrance where the course of the channel turns slightly south-eastwards, is suggested by a range of features including metalwork in the channel bed just upstream of a related beam slot. The putative launder entrance should be immediately upstream of these features, in the position (now) occupied by a hearthstone, immediately opposite a ramp-like feature of cobble construction. The most plausible explanation for this range of features, together with the historic map evidence, is that a launder did exist on the south side of the leat in this location, but its entrance was subsequently blocked, perhaps at a late stage in the history of the site. The cobbled surface on the north side of the channel might suggest that the launder entrance was culverted, but could equally post-date the infilling of an open channel; no evidence was found to support either view. The ramp-like feature on the south side of the leat opposite the putative sluice controlling flow into the launder may represent the end of a supplementary water channel, perhaps taken off the Hall burn or fed from drainage to the south-west. It is known from documentary records that water supply was a perennial problem for the operation of the mill, so it can be assumed that alternative sources were sought and all available supplies utilised. It is known that smelting capacity at the mill was extended in the 1750s and refining furnaces added around 1770, perhaps dating improvements made to the water supply via the leat, either through the construction of the original ‘Old Dam’ on the Devil’s Water – which, just conceivably, may have replaced the Hall burn at this time – or, much more likely, the construction of the ‘New Dam’ at this time further upstream from the original Devil's Water dam. The creation of a supplementary supply to the leat from the south is consistent with documented concerns to improve water supplies to the site.

Finally, the culvert itself is of interest for various reasons, not least because it extends for a distance of some 25 metres but appears to serve little purpose, other than allowing passage of the Dukesfield Hall trackway at its east end. The intervening section, between its western entrance and the trackway, seems to serve no obvious purpose, but in the context of the industrial operation of the site may have provided much-needed additional space for storage or intra-site movement of goods, horses and workforce. The various sockets in the west- and south-facing walls of the entrance to the culvert are unexplained, but it is just possible that the socket in the lower wall of the south-facing wall was a conduit of water to the smelt mill,

and that the socket in the west-facing wall of the entrance was part of the mechanism to control it.

3.4 *Trench 4* – 6m (length) x 4m (width)

Description (*Illus. 60-73*)

Trench 4 was excavated in low-lying mixed plantation woodland, between the track running past Dukesfield Arches and the Devil's Water. It was positioned to investigate a partly-exposed, truncated stone wall in an area known to have held buildings associated with the lead smelting works shown on an estate map of 1802 (ref.).

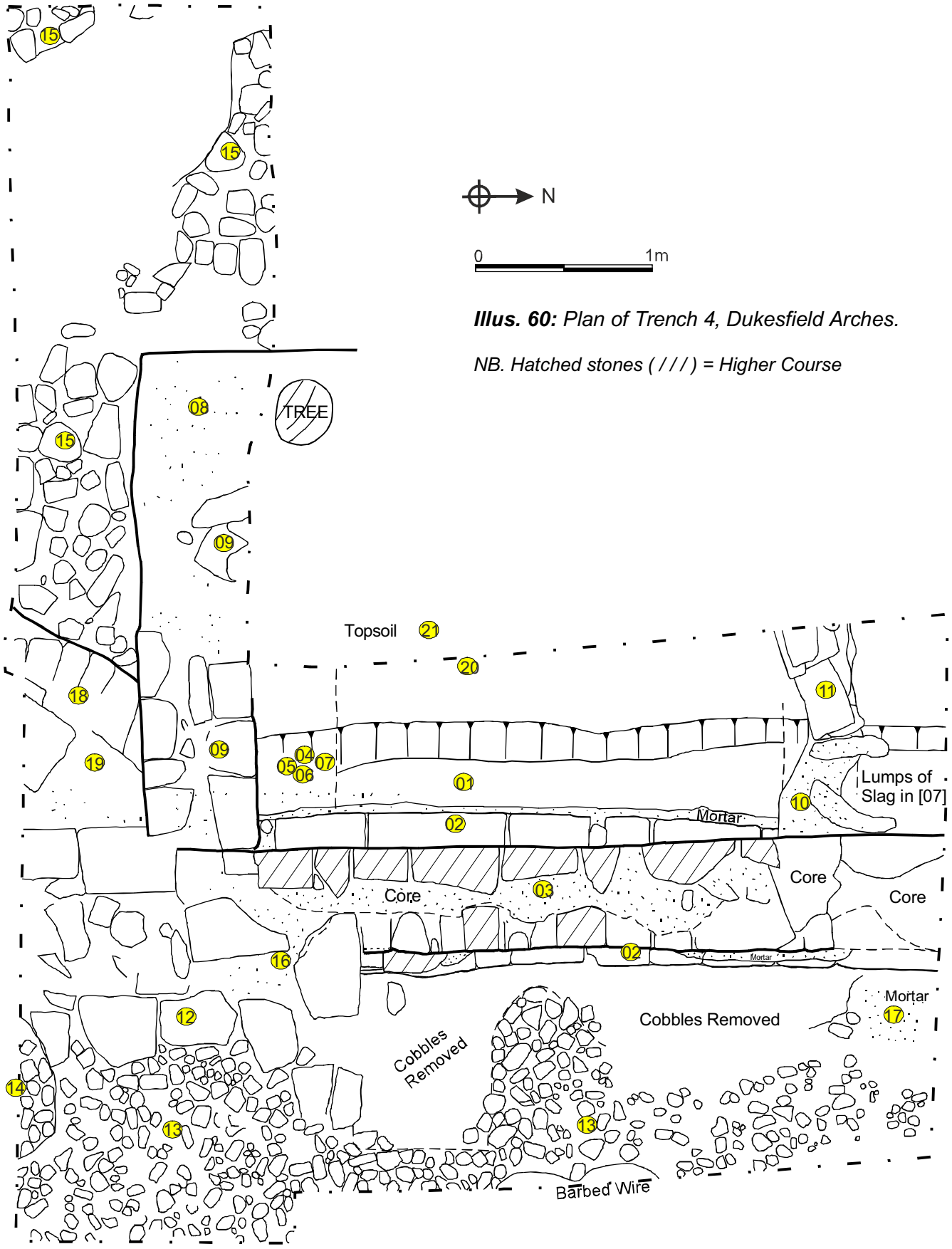
A rectangular area c.5m by 3m was initially opened straddling the exposed wall [403] which revealed two further walls ([409] and [411] running from its west face. The trench was subsequently extended to the west (3.6m by 1.5m) to investigate the extent of [409] and the nature of any associated deposits.

Alluvial deposits, medium-brown slightly-clayey silt overlying coarse and banded brown sand at a depth of around 0.6m, were seen in the western arm of the trench, within the foundation trench for wall [403] and to the east of this wall. The surface level of this deposit fell by about 0.4m east-west over the trench, almost certainly the result of terracing as the broad area around the trench was flat.

A substantial (1.5m wide by 0.65m deep) straight-sided foundation trench [401] was observed excavated into alluvial deposits. This ran north-south across the trench. A broad and deep foundation [402] (0.9m wide by 0.5m deep) consisting of large mortared sandstone slabs in a number of courses had been constructed along the trench, its east face set against the trench side. The wall constructed above this base [403], c. 0.6m wide and inset on both edges of the foundation, was of mortared rubble with a mortared core. A maximum of four courses survived; the east face of more irregular fabric and construction than the west.

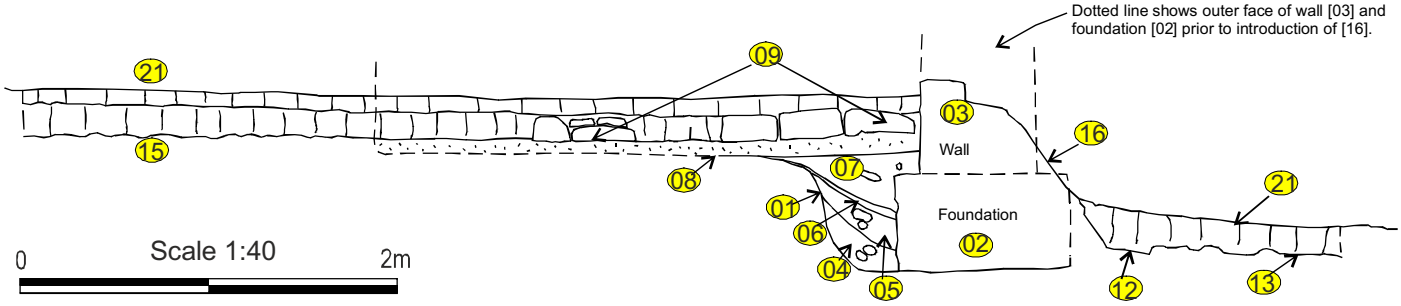
The open (west) side of foundation trench [401] had been filled as construction of the wall continued. Distinct layers included, from the base, khaki-brown gritty silt with many cobbles and stone fragments [4]; grey-brown gritty sand with some silt, loam and stone fragments [405] overlaid with a tip-line composed of sand and friable sandy mortar [406]. A dump of friable grey-brown gritty loam [7] which included many fragments of stone levelled the trench at the surface height of the alluvial deposit and nearly up to the top of the first west-facing course of the wall. Towards the northern end of the trench, a number of substantial lumps of slag [SF] were incorporated within this layer, possibly to reinforce the base of the overlying wall [411].

Subsequent to the levelling of foundation trench [401] two walls [409] and [411] had been constructed abutting the western face of wall [403]. Neither wall had any substantial foundations, with preparation limited to the laying (within a shallow cut towards the western end of [409]) of a bed of sandy, gravelly mortar ([408] and [410]) on top of which the walls were constructed. Survival of both walls was fragmentary. Wall [409] was 0.6m wide, and ran for 2.9m at a near right angle from wall [403] before either terminating or turning to the north. It was impossible to securely establish which because of the presence of a substantial tree at that point. Wall [411], of an uncertain width, ran for 1.2m obliquely from wall [403] into

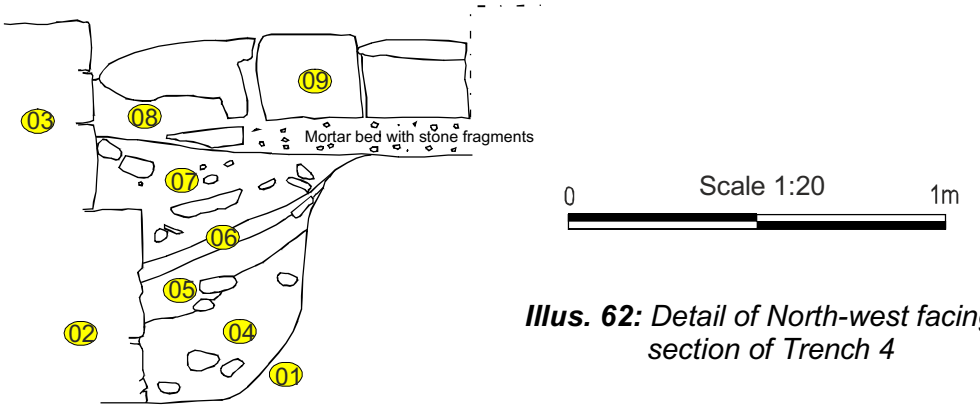


Illus. 60: *Plan of Trench 4, Dukesfield Arches.*

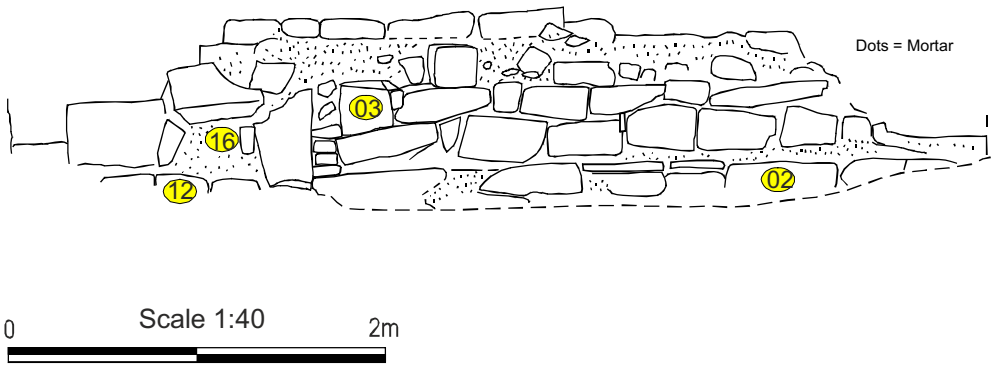
NB. Hatched stones (/ / /) = Higher Course



Illus. 61: *North-west facing section of Trench 4.*



Illus. 62: *Detail of North-west facing section of Trench 4*



Illus. 63: *South-east elevation of Wall [03] and Foundation/Plinth [02], Trench 4.*

Illus. 64*: View during the excavation of Trench 4, looking south at structural remains of a wall with cobbled floor in front.*

Illus. 65*: View looking southwards at structural remains in Trench 4.*

Illus. 66*: View looking west along a wall face (above) fronted by cobbling in Trench 4.*

Illus. 67*: Trench 4 viewed from the west, with a possible crucible shown in section within a construction trench in the foreground.*

Illus. 68*: View of Trench 4 looking north-east, showing the interior of a likely structure and a possible crucible shown in section to left foreground.*

Illus. 69*: Detailed view of a possible crucible shown in section within a construction trench in Trench 4.*

***Illus. 70**: View southwards of the remains of a N-S wall footings and cobbling in the south-east part of Trench 4.*

***Illus. 71**: View looking south of shallow-footed wall remains at the west end of Trench 4.*

***Illus. 72**: Detail of shaped building stones uncovered in Trench 4.*

***Illus. 73**: Detail of sandstone roof tile fragments from Trench 4.*

the western edge of the trench. It is possible that the walls linked and formed a discrete structure but this was not confirmed.

The fall in level of alluvial deposits east-west across the trench meant that the upper 0.2m of foundation [402] along its east face sat above ground surface, forming an exposed offset course.

Successive slab and cobble floors, now surviving only fragmentarily, extended across the trench to the east of [402]-[403] and were set directly over alluvial deposits. An area of slabs [412] towards the south end of the trench would appear to have been the earliest of these floors and abutted the robbed-out line of [402]. An angular and irregular cobble floor [413] survived intermittently to the east of [403] but was completely lost adjacent to the wall. A fragment of later cobbling [414] survived along the south face of the trench. A fairly insubstantial floor of irregular but well-rounded cobbles [415] also ran around the south and west sides of wall [409] sitting directly over the alluvial deposit. Parts of the floor to the west of [409] were lost. Along the south side of the wall, the floor was set in a shallow depression and appeared to have been disturbed.

At some point, both ends of wall [403] had been removed. Certainly at the south, and possibly at the north, the stubs were then re-modelled. To the south, this involved the formation of a crude surface about 1m wide [416] formed of mortar and large slabs sloping from the centre line of the wall to the east. At the northern end of the wall, substantial amounts of mortar [417] were spread to the east, but no specific structural adaptation survived. It is not certain if these features were in any way related to walls [409] and [411].

A probable robbing pit [418] was observed cut to the south of wall [409] and adjacent to foundation [402], cutting through cobble floor [415] and deposits below it. Possibly, the missing area of the east face of foundation [402] was removed during this operation. The pit was filled with unconsolidated rubble [419]. A substantial layer of loose and unconsolidated building rubble [420], with a concentration of brick to the base, directly overlay subsoil and butted against walls [403], [409] and overlay [411]. Whether the deposit was a demolition or levelling deposit is not certain. Finally, humic, loose woodland soil [421] lay over all deposits apart from the exposed face of wall [403].

Other than worked stone, including two apparent kneeler stones for supporting inclined coping on the slope of a gable, and fragments of sandstone roof tile, no significant artifactual discoveries were made during the excavation of Trench 4, but some large pieces of slag – including one of crucible form – were recovered from secondary contexts, where they appear to have been used to infill construction trenches or support building foundations and floors. The initial examination of the slag by nationally-renowned specialists, including David Cranstone and Dr Tim Young suggested that this slag may result from ironworking rather than lead smelting; further testing is proposed in order to resolve this.

List of Contexts

[401] Foundation Trench
Broad (1.5m) and deep (0.65m) trench for foundation [2] running north-south across Trench 4. Disturbed at south of trench by robber pit [418]. Above alluvium, under [402].

[402] Foundation

Substantial foundation for wall [403] set in foundation trench [401], 0.5m deep and around 0.9m wide in four, mortared courses. Top course very substantial blocks, more irregular lower courses. Above [401], under [403].

[403] Wall
Wall 0.6m deep and surviving to a maximum of four courses (0.7m) of mortared sandstone rubble with mortared core set centrally on foundation [402]. In general, it is of poor fabric and poor construction. Truncated to both north and south, it survives for a length of 4.4m. Above [402], butted by [408] and [411].

[404] Layer within Foundation Trench [1]
Khaki-brown gritty-silt with some gravel lenses. Above [401], under [405].

[405] Layer within Foundation Trench [1]
Grey-brown gritty-sand with some loam and gravel and pebbles. Above 404, under [406].

[406] Layer within Foundation Trench [1]
yellow-brown mortar and silty-loam in a distinct tip line. Above 405, under [407].

[407] Layer within Foundation Trench [1]
Grey-brown friable gritty-loam with many stone fragments. Above [406], under [408].

[408] Mortar Bed
Yellow brown mortar bed for wall [409]. At western end set in a slight footprint. Above [407], under [409].

[409] Wall
Fragmentary remains of wall 0.6m wide and 2.9m long abutting and running at near right-angle from [403]. Partial survival of one course of very irregular sandstone blocks. Whether western end was a termination or corner was not established. Above [408], butts [403], abutted by [420], under [421].

[410] Mortar Bed
Yellow brown mortar bed for wall [411]. Above [407], under [411].

[411] Wall
Fragmentary remains of wall abutting and running obliquely from [403]. Partial survival of one course of very irregular sandstone blocks. Runs into western edge of trench. Above [410], butts [403], under [420].

[412] ?Slab Floor
Six flat slabs adjacent to the east face of wall [403]. Probably represent a floor, others possibly obscured by later cobbling [413]. Above alluvium, ?butts [402], under [413].

[413] Cobble Floor
Intermittent remains of a cobble floor extending to the east of wall [403]. Lost adjacent to wall [403] but presumably butted against the wall originally. Above [412], under [414].

[414] Cobble Floor
Fragment of a cobble floor to the east of wall [403]. Above [413] under [421].

[415] Cobble Floor
Intermittent remains of a cobble floor to the south and west of wall [409]. Irregularly-shaped but well-smoothed cobbles set directly above alluvial deposit. To the south of [409] cobbles

set in a shallow depression and at some time disturbed. Above alluvium, butts [408], under [421].

[416] Sloping Surface
Following the truncation of the ends of wall [403] the southern stub was re-modelled with a sloping face to the east about 1m wide formed largely of stone slabs set in mortar. The function of the sloping surface has not been established. Above [403].

[417] Mortar Spread
A spread of mortar at the northern stub end of wall [403] running over cobble floor [413] to the east. Above [13], under [421].

[418] ?Robbing Pit
A pit to the south of wall [409] and west of wall [403] possibly cut to remove, or rob, blocks from wall foundation [402]. Above [415], filled by [419].

[419] Fill of [18]
Unconsolidated rubble dump. Above [418], under [421].

[420] Rubble Deposit
A spread of unconsolidated rubble to the west of [403], north of [409] and overlying [411]. Bricks more common to the base. Above [411], under [421].

[421] Topsoil
Thin, humic and loose dark brown woodland soil overlay all features other than the exposed area of wall [403].

Interpretation

Trench 4 revealed the remains of a substantial built structure, in the form of a north-south wall, with areas of internal and external cobbling, and ancillary structures of a later phase built onto its west side. The position of this building suggests that it may have served as a refinery built as an addition to the smelt works in or about 1765. There is no further evidence to shed light on its possible function, although significant amounts of slag and lime were found in the trench, suggesting that industrial processes occurred there.

The slag found in Trench 4 is of two types, a dark grey tap slag and a coarser, iron-rich coagulate incorporating metal and stone. These are suggested by David Cranstone as originating from a water-powered bloomery, and/or a finery forge. A bloomery smelts ore direct to wrought iron (via hammering) whereas a finery burns the carbon out of pig iron from a blast furnace to convert it to wrought iron (also with much hammering). The slags from Dukesfield are not typical for finery forges, and Tim Young reports similar slags from water-powered bloomeries. Cranstone's working hypothesis is that there was a water-powered bloomery (perhaps slater Medieval) on the later smeltmill site, possibly converted into a finery forge to process the iron from the blast furnace downstream – he suggests that the name, Furnace Wood, on the west bank of the Devil's Water 800 metres downstream of the smeltmill site, is probably derived from an early blast furnace site - and the water supply, along with some earlier buildings, re-used for the smeltmill. It may be that the original water supply for a putative bloomery/finery works was the Hall burn and that the leat from the Devil's Water was constructed when the smeltmill was established and needed a better water supply.

3.5 *Trench 5* – 5.60m (length) x 5.20m (width)

Description (*Illus. 74-82*)

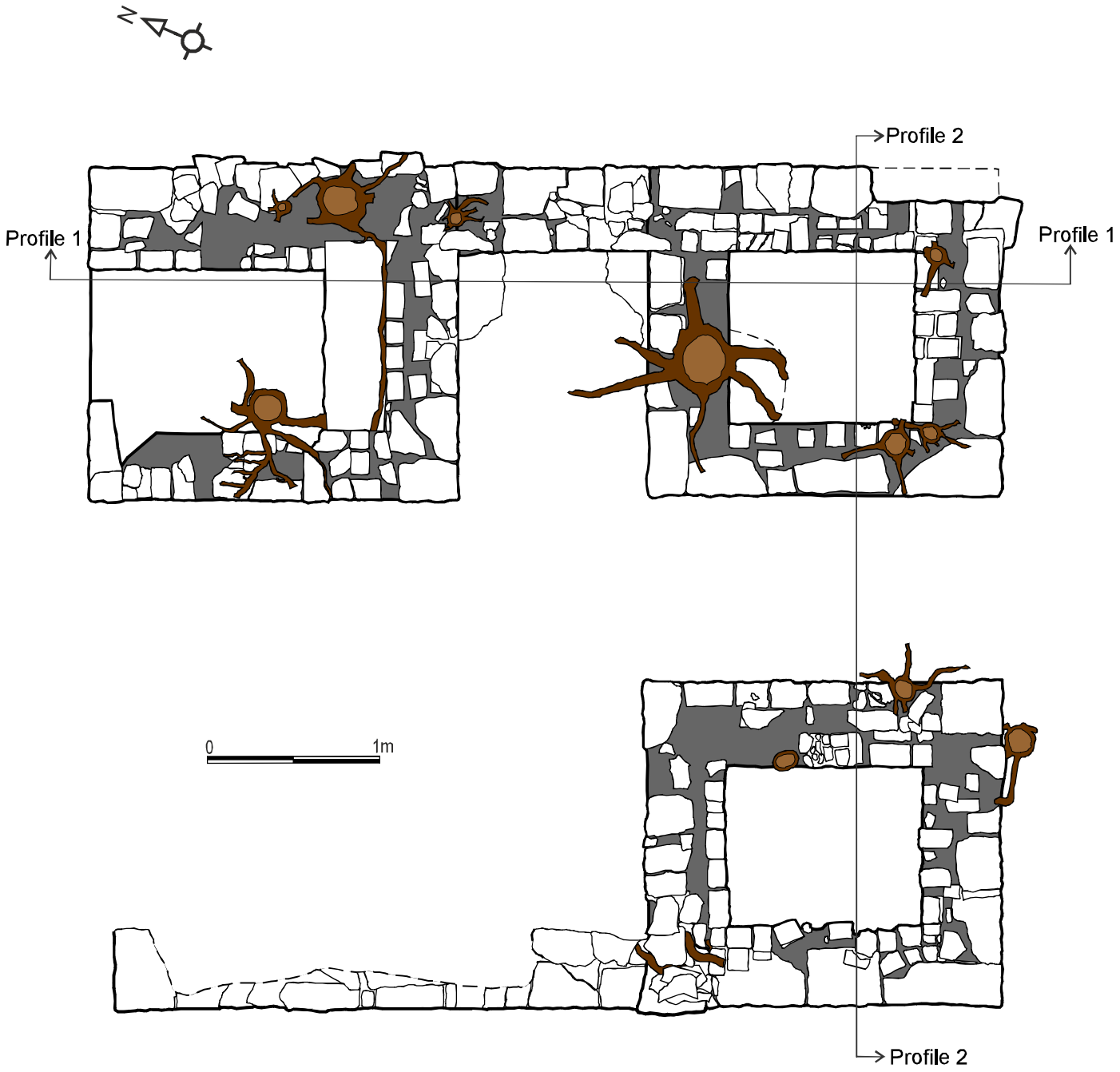
Trench 5 was excavated over the remains of three out of four chimney bases, the site of which was known from historic map evidence and a previous episode of consolidation work on a hill at the south-east end of the arches. Some masonry was visible here prior to excavation, but the mound formed by the chimney bases was buried beneath pine litter and partly obscured by pine samplings which had colonised the leaf litter infilling the individual chimneys.

The removal of leaf litter and tumbled masonry revealed the form and structural composition of the chimney bases, which were square in plan and arranged at the corners of a larger enclosure, the outer walls of which were constructed of regularly coursed sandstone masonry, best seen in the north part of the south-west elevation which is upstanding to c1.5 metres. This formed a square structure with sides of 5.7 metres in the corners of which were positioned the four chimney bases, each measuring 2.2 metres square, the outer sides of which were formed by the general enclosure wall, with the inner walls constructed of the same small, flattened blocks of sandstone masonry. The inside walls of the chimneys were lined by a single skin of red brick, probably from a local source (brick clays excavated from the current Folly Plantation, formerly Mill Bank, some 250 metres south-east of the smeltmills site, supplied a tile works on that site in the second half of the 19th century). The positioning of the chimneys at the four corners of the wider stack site leaves a cruciform-shaped area between them, which it is suggested may have been used for access and maintenance purposes.

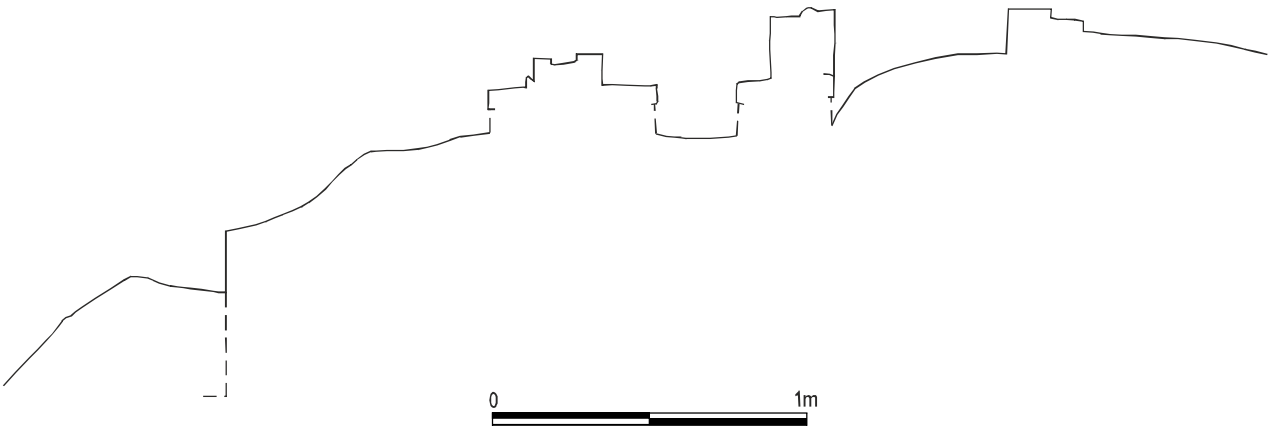
Further excavation of the chimneys, particularly on the north side of the north-east chimney, revealed a flue extending from the direction of the arches under the flagged floors of the two northern chimneys to exit into the two southern chimneys. Given the constraints of time and safety considerations, it was not possible to excavate deeply enough on the north side of the north-east chimney to locate the bottom of that structure or its junction with a flue extending from the arches.

Interpretation

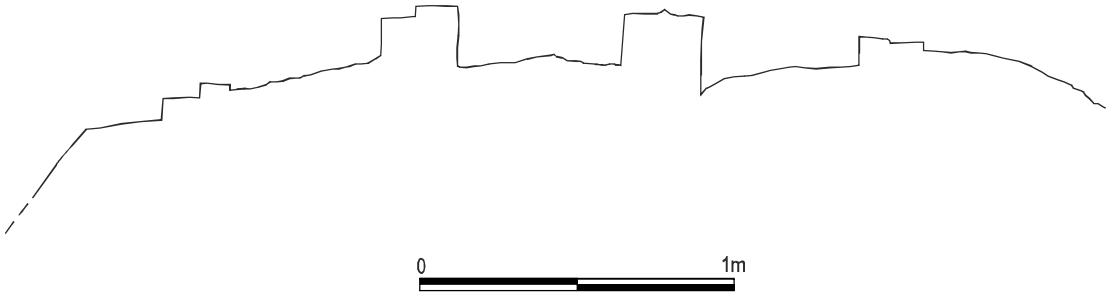
Trench 5 revealed a stack of four separate chimneys within a single walled enclosure; it is likely, as suggested by historic photographic evidence, that the individual chimneys rose separately from the larger walled structure which defined the base of the communal stack. The chimneys were used to disperse fumes from the smeltmills, to which they were connected by flues extending horizontally over the surviving stone arches. The method be which the horizontal flues connected to the chimnies is suggested by evidence gained during the current excavations. It appears that flues from the north-west extended under the flagged floors of the first (northern) set of chimneys in order to release fumes into the rear (southern) chimneys. The northern pair of chimneys must, therefore, have been supplied by flues connected at a point above the currently-surviving masonry. The method by which the fumes being carried over the arches divided into four flues is unknown; nor it is known how many flues were carried by the arches, but certain structural evidence suggests evidence for two. An alternative possibility is that only two of the four chimneys were in use at any given time, with the flues extending below the chimneys being manipulated according to which chimneys were in use; those not in use being subject to cleaning and maintenance.



Illus. 74: *Plan of The Chimney bases excavated in Trench 5.*



Illus. 75: *Profile [1] through chimney bases excavated in Trench 5 at Dukesfield Arches.*



Illus. 76: *Profile [2] through chimney bases excavated in Trench 5 at Dukesfield Arches.*

Illus. 77*: View looking north-east at the south corner of the chimney-bases exposed in Trench 5.*

Illus. 78*: View looking north-west at the north corner of the chimney-bases exposed in Trench 5.*

Illus. 79*: View looking west from the north corner chimney base exposed in Trench 5.*

***Illus. 80**: View looking north-west across the south-east corner chimney-base exposed in Trench 5.*

***Illus. 81**: View looking north-east across the walled space between the north-east and south-east corner chimney-bases in Trench 5.*

***Illus. 82**: View looking south-east at the north-west face of the north-east corner chimney base exposed in Trench 5.*

It remains uncertain why such a short length of horizontal flue was created at Dukesfield, although its immediate purpose, to connect with the chimneys above the smelting hearths and raise the fumes to a level where they could be more safely released, is reasonably clear. The benefits of horizontal flues were known at the time of the construction of the arches, and the high price of lead during the Napoleonic Wars prompted smelt mills in Allendale to create long horizontal flues running up hillsides, from the inner brickwork of which valuable deposits of lead and silver were worth reclaiming for secondary smelting. The Dukesfield Arches point uphill towards 'Leadpipe Hill' on the once open moorland a mile to the south, but no flue was ever constructed there, and compared to the much longer flues constructed in the first decade of the 19th century from the Rookhope, Langley and Catton mills the horizontal flue at Dukesfield seems too short to have been worth the expense of construction. It has been suggested that the Dukesfield arches were built to test the effectiveness of horizontal flues for the purpose of reclaiming valuable accretions, but it is also possible that the arches may also, or originally, have been intended to perform another function, perhaps bringing water to the site from the Hall burn. Questions regarding the purpose and modus operandi of the chimneys and horizontal flues can only be approached through further examination of the structural evidence at the base of the chimney stack, upon the arches and at the foot of the arches, enhanced by documentary and comparative evidence.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The excavations carried out at Dukesfield in October 2012 explored some of the main features of the site visible as earthworks and built remains, while geophysical survey explored areas of the site where further building remains were expected and documentary work added social and economic context to the physical remains explored.

The results of geophysical survey, undertaken in difficult conditions, did not provide compelling evidence for buried archaeological remains, but this alone does not represent evidence for the absence of such remains.

The subsequent excavations were considerably more revealing, providing evidence for a wide range of structural elements some of which lend themselves to secure interpretation, while others present further questions the solutions to which can only be approached by combination of additional fieldwork, materials analysis and documentary evidence.

Trench 1 encountered a rubble deposit of stone and brick fragments probably deriving from the collapsed north end of the current arches, which presumably formed part of the support carrying a flue (or flues) from the smelt mill to the chimneys. A wall found under a considerable depth of deposit and continuing to at least 1.2 metres bgl suggests the remains of a substantial building which is considered likely to belong to an earlier phase of industrial activity on the site, perhaps arranged parallel to the original course of the Hall burn. However, the relationship between the excavated remains and current arches can only be tested by further excavation

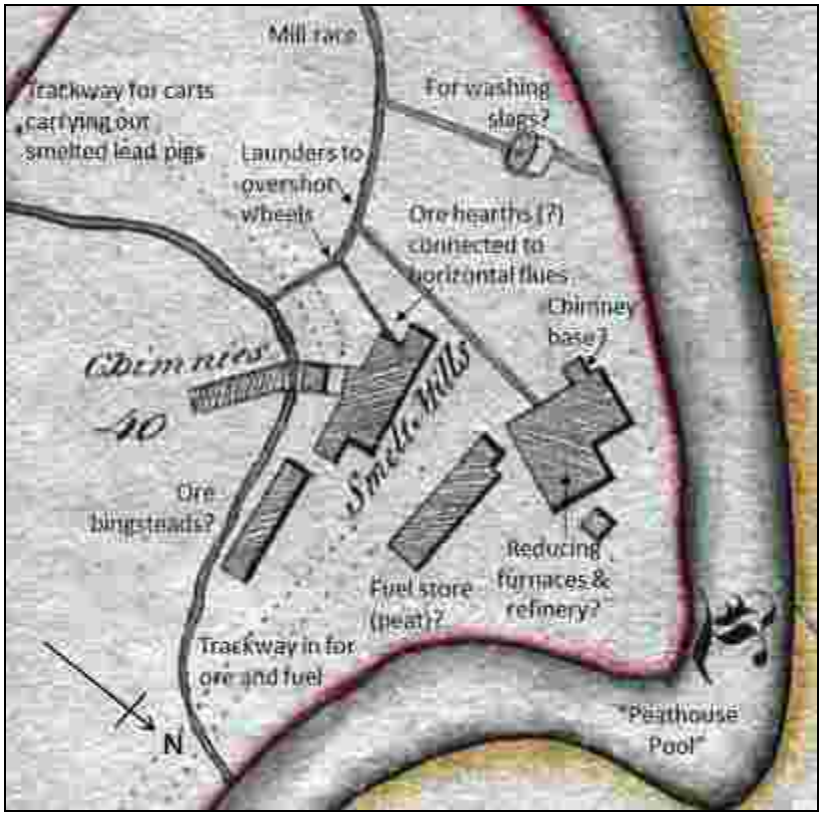
The stonework remains exposed in Trench 2 were those of the top of the culvert roof as it runs under the trackway to Dukesfield Hall, and its eastern entrance which allows the outflow of the leat into the Hall burn. It appears from its form of construction and disruption to the culvert top that the present outflow opening is not original, but has been replaced at some stage, perhaps when the lower course of the hall burn was formalised by the construction of a wall connecting to the arches.

Trench 3 excavated part of the course of the mill leat where cuts in the bank on the north side suggested the possible locations of the sluice gates which regulated the flow of water taken off the Devil's Water and directed down the lauders to the mill buildings. A wide variety of features were revealed, including surviving elements of the leat channel and culvert entrance. Most surprisingly, and perhaps uniquely, it was found that the greater part of the exposed leat channel and part of its sides were formed from fused hearthstones, presumably discarded from the smelt mill, suggesting that they represented a relining of the leat. The presence of launders controlled by sluice-gates was suggested in two locations by worked stones and features within the channel bed, although no visible opening for a subsidiary channel or launder was detected. A ramp-like feature on the south side of the leat opposite clear remains of a sluice is suggested as the remains of a supplementary water channel, perhaps taken off the Hall burn or fed from drainage to the south-west.

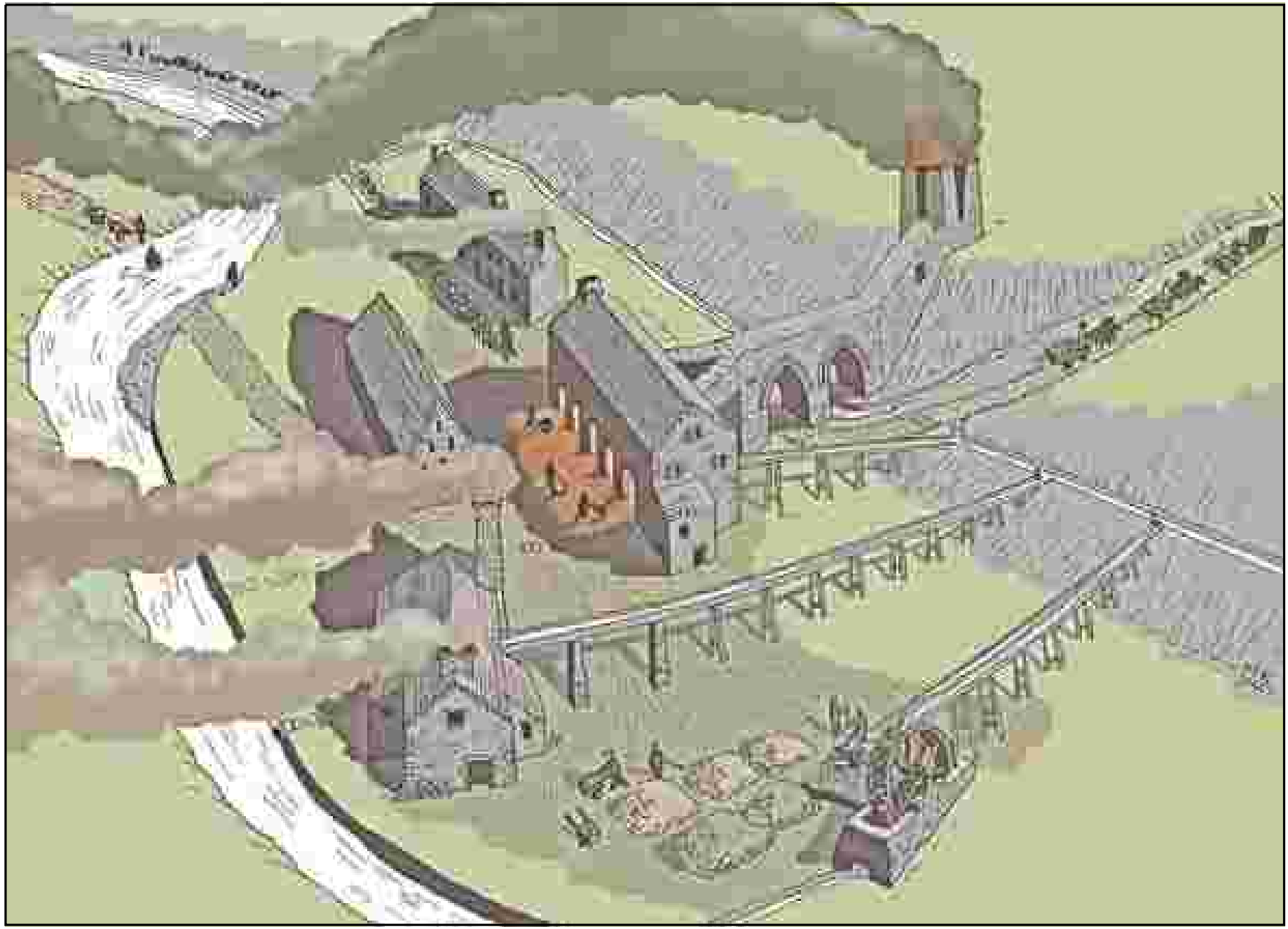
Trench 4 revealed the remains of a substantial built structure in a position consistent with its use as a refinery, built as an addition to the smelt works in or about 1765. However, slag found in secondary contexts has been initially identified by specialists as originating from ironworking, specifically from a water-powered bloomery, and/or a finery forge, leading to the working hypothesis that there was a water-powered bloomery on the later smeltmill site, possibly converted into a finery forge to process the iron from a blast furnace downstream in the environs of Furnace Wood. This may support the theory, also suggested by the wall found in Trench 1, that the original water supply for a putative bloomery/finery works was the Hall burn and that the leat from the Devil's Water was constructed when the smeltmill was established or extended and needed an improved water supply.

Trench 5 revealed a stack of four separate chimneys within a single walled enclosure south-east of the arches. The chimneys were used to disperse fumes from the smeltmills, to which they were connected by flues extending horizontally over the surviving stone arches. The method by which the horizontal flues connected to the chimneys are discussed, but it remains uncertain why the horizontal flue was created at Dukesfield when it seems too short to have been worth the expense. It is emphasised that questions regarding the purpose and modus operandi of the chimneys and horizontal flues can only be approached through further examination of the structural evidence, supported by documentary and comparative evidence.

The arrangement of buildings and basic organisation of activities on the site in its later 18th century and early 19th century phase is now reasonably clear, as represented by the following analysis of the 1802 estate plan:



Illus. 83: *The 1802 estate plan of the site with interpretive text by Greg Finch.*



Illus. 84: Interpretive drawing of the site prepared by Peter Ryder on the basis of the 1802 estate plan and evidence derived from excavation.

Less clear, however, is the layout of the site prior to the 1760s, or whether the industrialisation of the site occurred in more than one phase from possible beginnings in the mid-16th or, more likely, second half of the 17th centuries. Areas of doubt surround the nature of 16th and 17th century industrial activities on the site, specifically whether lead smelting or, as suggested by slags recovered from the excavations, ironworking was originally practiced, and whether the Hall burn was initially used as the main water source for the site, win which case mill buildings might be expected to have been arranged parallel to it. A specific question concerns the relationship between the wall remains found in Trench 1 with the surviving arches structure, with the former suggested to represent an earlier phase of activity on the site. Other areas of uncertainty include the modus operandi of the chimneys and their relation with the putative flues carried by the surviving arches, and the methods by which water was taken off the main, hearthstone-lined leat, by means of launders, which could not be properly investigated as part of the evaluation strategy. These three sites certainly merit further exploration in order to elucidate the phasing and operational history of the site, and reveal structures for consolidation and/or display. It remains to be commented that the area north of the main east-west access track through the site, although shown on early plans to contain buildings of industrial importance, remains largely inaccessible due to tree cover which, even if removed, is likely to have impacted negatively upon the archaeological potential of that area. Therefore, unless circumstances change considerably, it is not suggested that further invasive work would be productive in that area.

4.2 RECOMMENDATIONS

It is recommended on the basis of the evaluation work reported here and supported by documentary evidence that the following elements of the site should be further investigated with a view to public interpretation and display:

1. The area in front of the truncated north elevation of the arches should be investigated by widening and deepening the trench opened in October 2012, with the aim of establishing the extent, depth, character and chronological phasing of remains known to be present there. Specifically, the relationship of the excavated wall remains with the present arches should be established, by excavating up to the footings of the arches following suitable consolidation work on the upstanding structure.

2. The excavation of the leat south-west of the arches should be extended to include the section excavated in October 2012 with an additional section to the west. The purpose of this will be to expose features for consolidation, interpretation and display, and to answer questions about the nature of the water supply to the smeltmills and to explain changes to this supply over time.

3. The excavation of the chimney bases should be repeated and extended to include the area between the chimneys and the end of the arches upon which the horizontal flues from the smeltmills rested. The purpose of this will be to expose features for interpretation and consolidation.

5. REFERENCES

Richard Carlton, Greg Finch & Paul Frodsham, 2012, *Dukesfield Lead Smelt Mill Arches: Community Heritage and Conservation Project;* The Historical Metallurgy Society, Research in Progress Conference, Tuesday 6th November, 2012, Research Beehive, Newcastle University.

Linsley, S. M, 2006, *The Life and Times of Thomas Dixon 1805 – 1871.* Wagtail Press, Steel, Hexham.