MEDIEVAL RURAL LEAD WORKING: EXCAVATIONS AT LINCH CLOUGH, UPPER DERWENT VALLEY, 2000–2001

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INTRODUCTION

An archaeological feature betraying evidence for industrial activity was first discovered by Bill Bevan and Mark Edmonds while undertaking Phase 1 of the Upper Derwent Archaeological Survey in 1997 (Bevan 1998). The small complex from surface inspection appeared to comprise a dish-shaped industrial hearth associated with an oval platform, areas of waste dumping and other potential features. The site was interpreted as a lead working hearth dating from the medieval or post-medieval periods. Some erosion from sheep was identified at this time. Areas of exposed soil and disturbed ground had become more extensive in 1998 when the site was revisited to complete a measured surveyed. It was decided to undertake excavation of this potentially important site for interpreting the region's small-scale rural industrial archaeology. Fieldwork was undertaken in 2000 and 2001 to rescue the feature from ongoing erosion as well as to determine its date of use and the nature of activities associated with it.

LOCATION

The hearth is located at approximately 310m OD, immediately to the north of the watercourse on the only area of reasonably level ground within the steep-sided Linch Clough, a tributary of the Derwent River near to its source in the High Peak (Fig. 1; Plate 1) (SK 165943). Along its northern edge runs a terraced trackway (Bevan 1998a) that partly overlies and post-dates the hearth. The surrounding landscape is typical of open clough-sides, comprising course grasses, heather, bracken and intermittent scrub.

RATIONALE AND EXCAVATION METHOD

The rationale for excavating the feature was to rescue it from ongoing erosion as well as to assess its date and the nature of activities associated with it. Between site visits in 1997 and 1998 observed erosion had become significantly worse and discussions with the

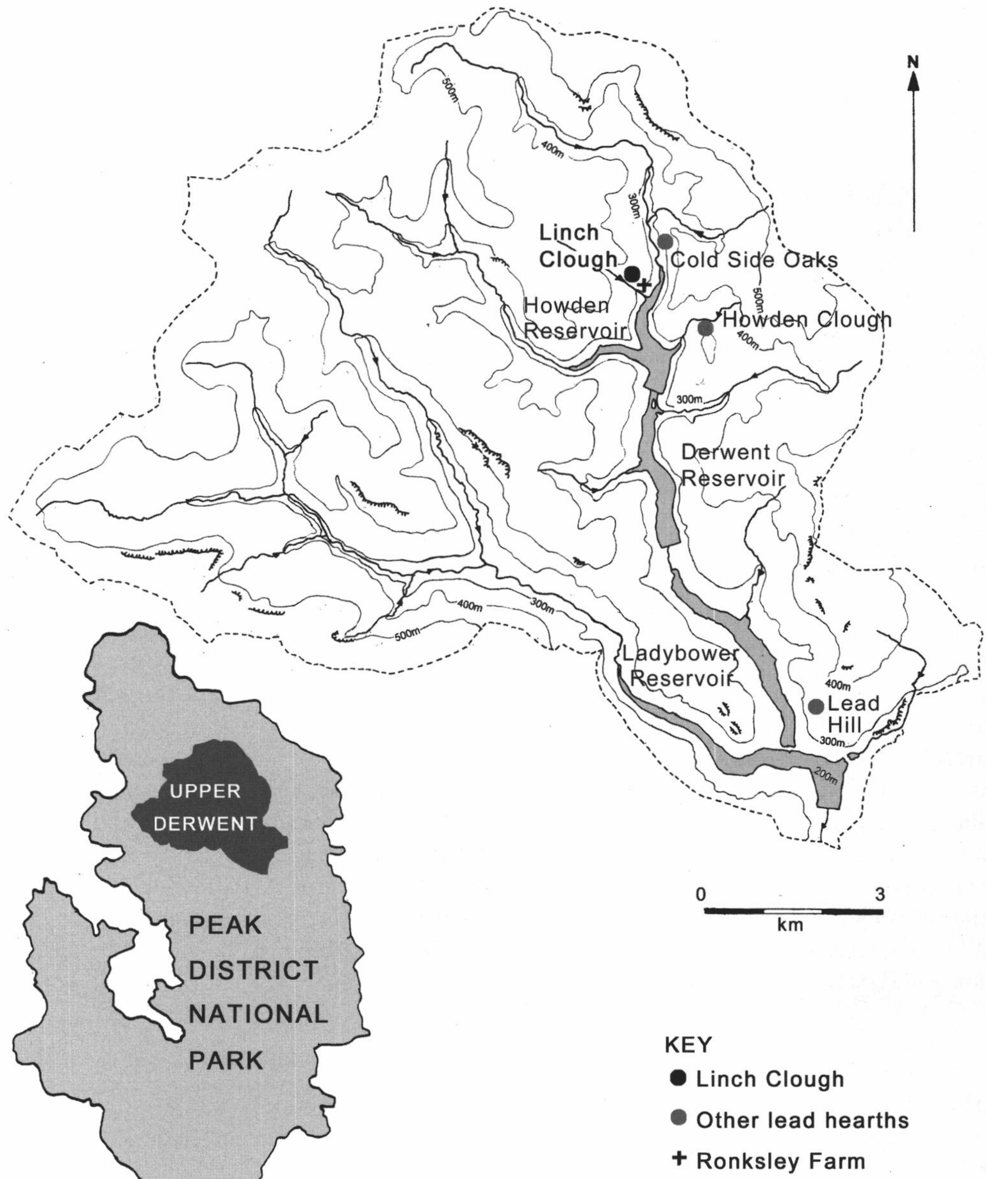

Fig. 1: Location of the medieval lead working hearth at Linch Clough.

landowner, the National Trust, suggested that there were no easy solutions to preventing this from continuing. Excavation would allow us to preserve the site by record and give us the rare opportunity to investigate such an industrial hearth. This would enable us to identify the types of features and activities associated with such a hearth and obtain a date for its use. This would be important information relevant to the history of the Peak

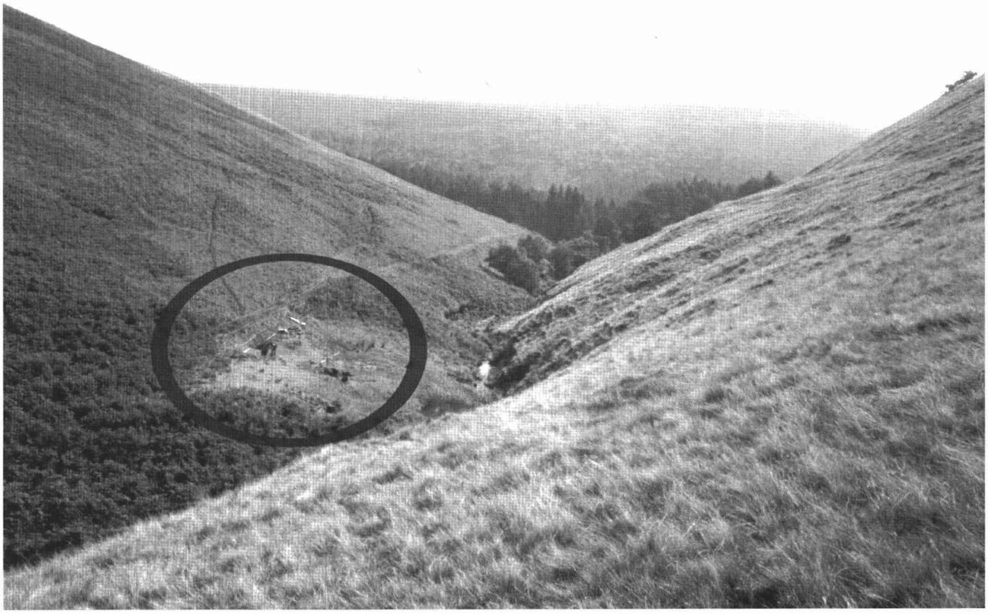

Plate 1: The lead hearth prior to excavation and in its landscape setting, looking east along Linch Clough.

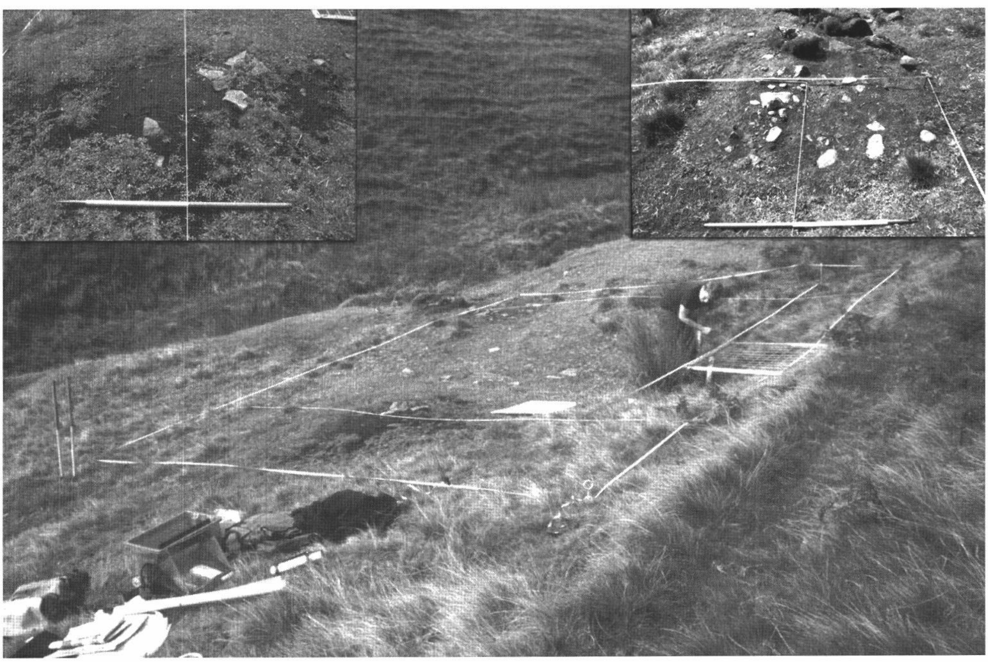

Plate 2: The hearth before excavation showing two of the erosion areas (insets).

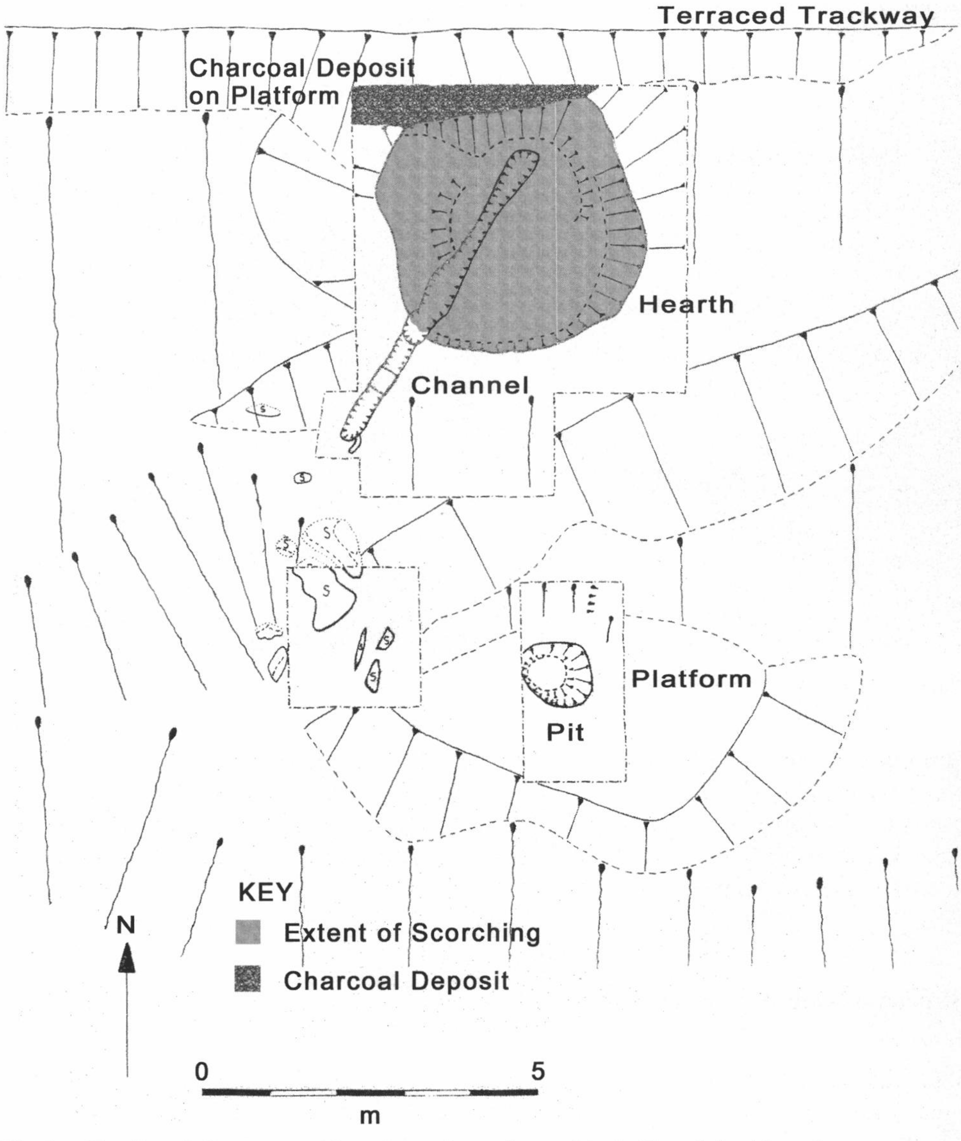

Fig. 2: Earthwork features and locations of trenches at Linch Clough lead hearth.

District's lead industry, which has been an important element in the region's landscape since at least the Roman period. It would also help to interpret similar features identified in the Upper Derwent and subsequent finds of burnt stone and lead slag have been discovered in the draw down zones of the reservoirs by Paul Ardron and Frank Robinson (*pers. comm.*).

Three areas within the complex were identified for excavation, both for their apparent archaeological value and the location of erosion (Fig. 2; Plate 2). An area measuring 6m by 5m was deturfed to expose the full extent of the dish-shaped hearth (feature A).

Plate 3: The hearth under excavation showing dish-shape, scorched/pink ground (dark area in centre), channel and overlying trackway.

Subsequently two smaller areas were opened around the large boulders immediately south-west of the hearth (feature F) and the sub-circular platform (feature B). All potential archaeological features were then excavated by hand. Each archaeological deposit (defined as a context) was recorded individually and representative samples taken for specialist analysis.

RESULTS OF EXCAVATION

Structural Features by Bill Bevan

Hearth

This was the most prominent of the features surviving above the ground surface. Prior to excavation it could be seen to be an elongated, dish-shaped, flat-bottomed depression cut into the sloping clough-side. The sides of the dish are not continuous but open to the downslope side. When visited in 1997 the sides were continuous with a shallow rim on the downslope side. However since 1997 erosion caused by sheep using a supplementary feeder placed in the bottom of the hearth has removed this rim and extended the area of exposed ground.

Hearth Cut and Fills

The hearth is a simple, shallow, sub-rectangular scoop [context 1028] in the clough side, measuring 3.8m east-west, 3.5m north-south and 0.20m deep (Fig. 3). It had been hand-dug into the underlying natural silty-sands and had naturally embedded stones protruding through into the hearth area, so creating an irregular bottom and sides. The

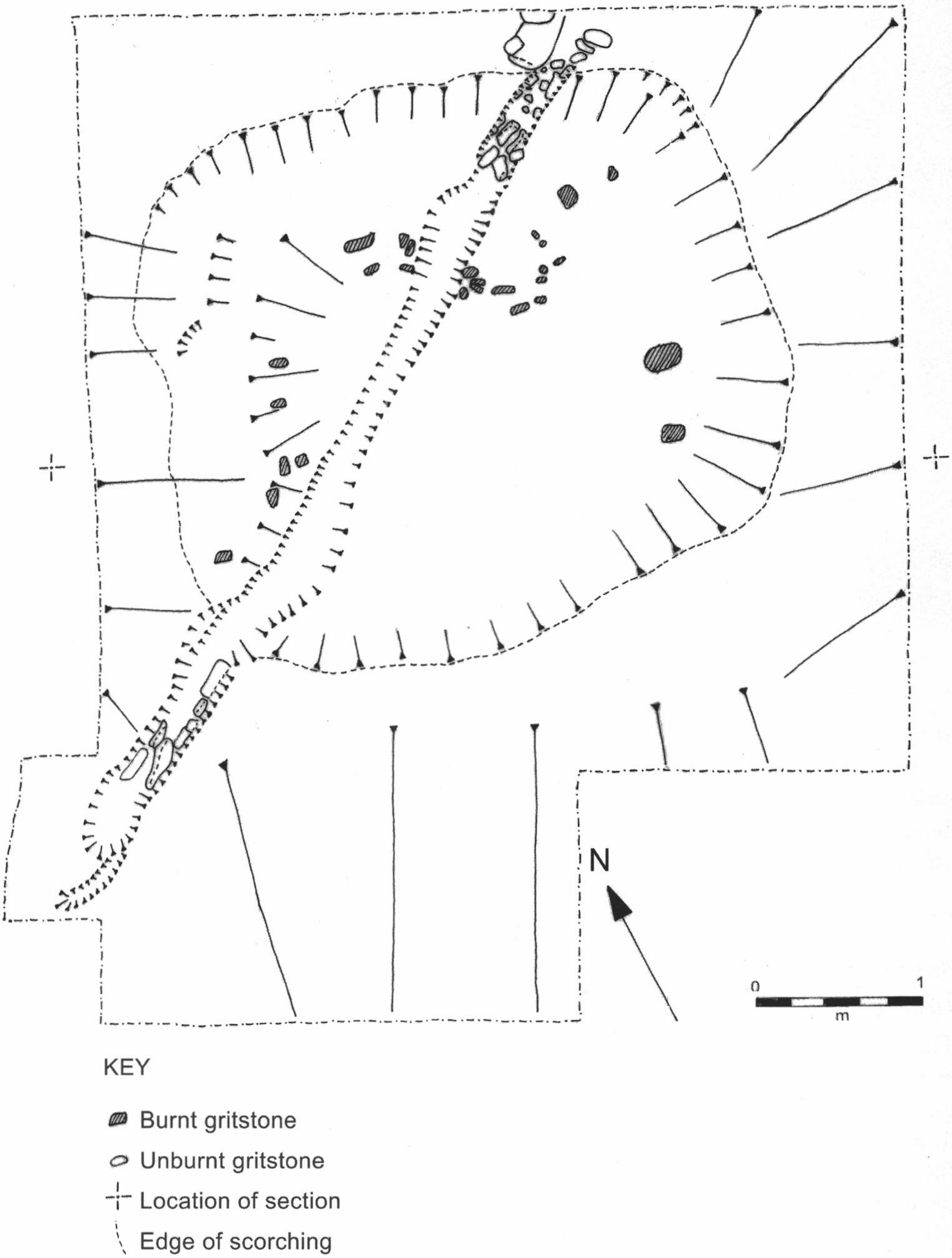

Fig. 3: Excavation plan of the Linch Clough hearth.

bottom is virtually level, gently sloping down from north-west to south-east by a maximum of approximately 0.10m (Fig. 4). The sides form gradual breaks-of-slope with the bottom, rising to obvious breaks with the surrounding ground surface to the south,

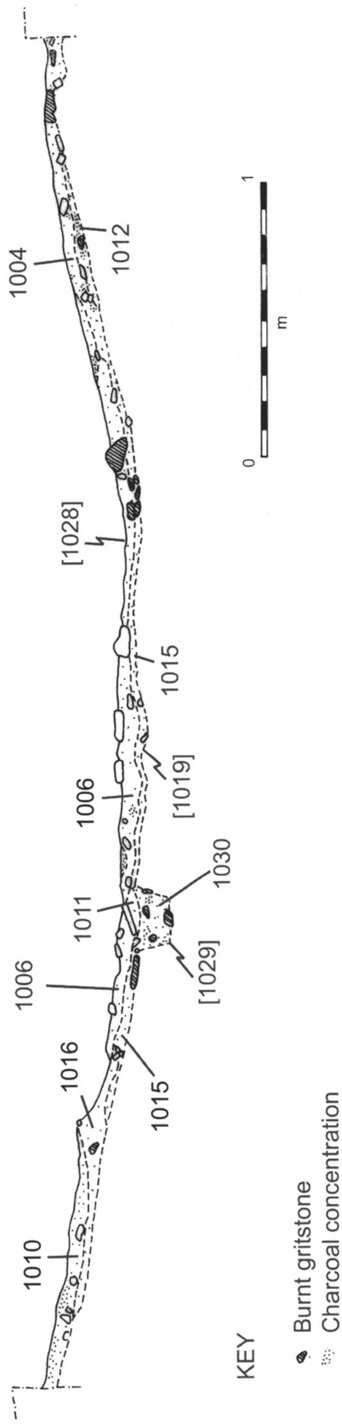

Fig. 4: Section through deposits in the Linch Clough hearth.

east and north of the hearth. To the west the side rises in a series of steps, possibly caused by the later removal of the smelted lead.

Within the confines of the hearth itself the ground surface has been burnt, resulting in a pink colouration of the subsoil. This has a very distinct and abrupt edge around the upper rim of the hearth which shows that the extent of burning corresponds exactly with the hearth itself. To the west this burning continues on to the more level ground surface.

Within the hearth are two deposits of industrial waste comprising burnt soil, burnt gritstones (some covered in a glaze-like lead deposit), lead waste, slag and charcoal [contexts 1015, 1026].

One of these deposits [context 1015] was located in a smaller sub-rectangular scoop [context 1024], 3.7m long, 2.1m wide and 0.20m deep, which had been cut into the other industrial deposit [context 1026] (Fig. 4). These two distinct layers of waste could be the result of a single-phase of smelting, with the apparent later deposit representing the area within the hearth turned-over to extract the smelted lead. Alternately they could be derived from two separate episodes of smelting with the hearth for the later one having been a smaller feature cut into the *in situ* waste from a previous smelting episode. The surviving waste in the hearth would therefore be the result of the last one or two smelting operations carried out on site.

Covering the two deposits of industrial waste was a low pile of unburnt stones [context 1022], which was deposited after the hearth had been abandoned and cooled (Fig. 4). However, it is impossible to identify whether the stones were piled here soon after the last smelting and by people connected with the use of the hearth, or much later with their location being associated coincidently with the hearth. Overlying the stones and the industrial waste were two layers of silty-clay [contexts 1001, 1006] that had been washed into the hearth due to erosion of surrounding soils.

The gritstones appear to have been part of a structure enclosing the hearth, though no evidence for foundations was discovered during excavation. Gritstone is resistant to prolonged episodes of heating and is in plentiful supply in Linch Clough. Stones showed evidence for burning in both oxidizing and reducing environments. Many also had lead waste adhered to them in the form of a glassy green compound and lead oxide white crust. The most common deposit was dark olive green, thin and glassy that had the appearance of being of low viscosity and covered most burnt gritstone blocks. The lead oxide was a crystalline, pale green, lead silicate, frequently containing large metallic lead inclusions and being covered in a characteristic lead carbonate crust.

The nature of the waste suggests that smelting of lead ore took place in the hearth. Roger Doonan believes that the process best represented by the evidence from Linch Clough is that of the traditional Derbyshire Bole hearth, even though it is not in the traditional hilltop location. The waste is predominantly a by-product of smelting rather than deliberately produced slags. However, it appears to have used bellows or forced air, and charcoal fuel. There is only a small amount of galena evident and as it is not located in a traditional bole location, the possibility that it was a slag-smelting hearth cannot be dismissed.

Underlying Channel

Running under the hearth and extending both to the south and north is a small channel [contexts 1025, 1029, 1053, 1062] cut into the subsoil (Fig. 3). The channel varies

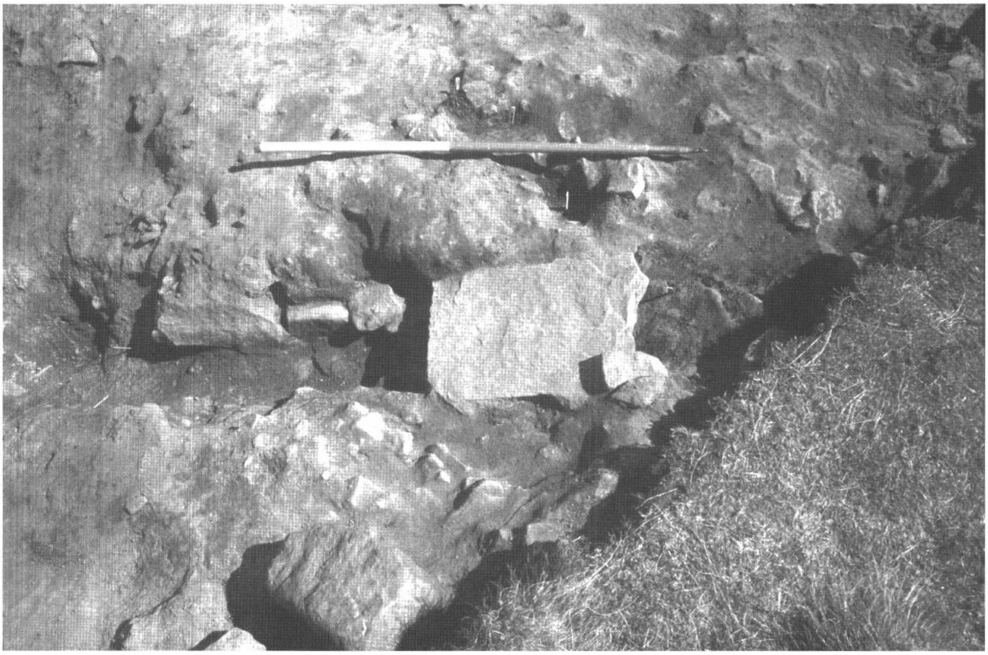

Plate 4: Southern end of channel where it is stone-lined and covered with a gritstone slab.

in width from 0.14 to 0.32m with a total length of 5.6m to the northern edge of the trench.

Where it lay directly under the hearth it was an open cut filled with industrial waste, which had been recut once, and was scorched along its sides and bottom from contact with hot material. The original cut and the recut each contained a different deposit of industrial waste [contexts 1027, 1030] corresponding with those in the hearth itself.

Where the channel extended outside of the hearth it was partly covered and lined with gritstones [contexts 1052, 1056, 1061, 1064]. Here it had not been subjected to any scorching, nor did it contain any industrial remains. Where the channel was covered with stone slabs it was largely voided except for a very loose, brown silty-sand containing fragments of charcoal [context 1050], which appears to be a post-abandonment deposit. At the southern terminus of the channel was an almost pure deposit of charcoal. Here the natural soil into which the channel was cut appeared to be truncated due to irregular erosion. This area of erosion is situated immediately south of a large slab [context 1052] which covers the channel (Plate 4).

The large slab [context 1052] measures approximately 0.55m by 0.40m and is located immediately below and south-west of 4 gritstone boulders [context 1040] arranged in a slight semi-circular line facing the hearth. One of these stones directly overlies the channel and the end of the slab nearest the hearth is supported by small chocking stones placed into the channel itself. Here the channel was wider than elsewhere and its sides were irregular suggesting that it had been eroded. The bottom of the channel rose slightly, by 0.05m, as it ran south from the hearth to its south-western terminal. A series of erosion hollows and ridges [context 1051] were cut into the ground as it sloped downwards to the south-west of the slab. The hollows were backfilled, either deliberately or through natural processes, with redeposited natural [context 1033].

The channel appeared to come to an end before the northern edge of the trench, its line and stone lining becoming irregular. However, any actual terminal was very unclear and the channel may have continued beyond the trench under the steeply sloping clough-side. Here the channel was overlain by a deep deposit of redeposited natural [context 1066] that originally was thought to be the natural slope of the clough-side. On excavation, we found it contained large pieces of charcoal and was a flat-topped platform covered with a deposit of charcoal (see below). This was further covered with redeposited natural and silt washed from the trackway, so giving the impression of being the natural clough-side. The earlier cut of the hearth was made into this overlying deposit that was also scorched pink from smelting. This shows that the creation of the channel pre-dated the cutting of the hearth, possibly as one of the first jobs undertaken when the hearth was originally constructed. It also involved a substantial amount of earth moving, which suggests that it had an important function requiring it to exit the upslope side of the hearth. However, due to the inconclusive nature of the channel at the trench edge, this function is unclear. The channel may have come to an end near the trench edge or continued beyond for an unknown length. If it did continue, within 0.5m the channel would have been overlain by the platform to a depth of over 1m.

Dumps of Industrial Material

The area surrounding the hearth contained a number of discrete dumps of industrial waste and charcoal. Most appear to be waste while one, to the north of the hearth and situated on a level shelf, may be a charcoal store.

Immediately to the north of the hearth, part of a 0.05m thick deposit of charcoal-rich soil and pure charcoal [context 1023] on a flat-topped platform [context 1045] was exposed within the trench. The extent of the excavated platform measured 3.80m by 0.72m and it continued both to the north and west of the trench. It had a sharp break of slope with the redeposited natural [context 1066] it was built on top of. The surface lay approximately 0.50m above the bottom of the hearth and varied from level to only 0.01m above the upper limit of burning on its northern, upslope, side. The charcoal completely covered the platform and had been deposited here cold, as evidenced by the lack of scorching on the platform's surface.

To the eastern, southern and northern edges of the hearth were a series of small dumps of industrial waste material:

On the north-western edge of the hearth three identifiable dumps of industrial waste [contexts 1010, 1011, 1016] contained various proportions of burnt stone, charcoal, ash and slag. Apparently none were deposited whilst still hot. Context 1016 formed an oval mound approximately 1.80m long, 1.10m wide and 0.02–0.08m thick. This was partly overlying the waste contents of the hearth [context 1015] showing that it was deposited after the final smelt had taken place.

On the eastern edge of the hearth were two identifiable dumps [contexts 1004, 1012] dumped here when hot, as evidenced by the scorched soil below. Context 1004 was a deposit of brown-black sandy clay forming an irregular low mound, 2m (to the trench edge) by 2.4m and 0.05–0.10m deep. This overlies the waste contents of the hearth [context 1015] showing that it was deposited after the final smelt had taken place. It was also interleaved with a post-abandonment erosion deposit [context 1006], which demonstrates that it was eroded with material washed downslope.

To the south of the hearth were three identifiable dumps [contexts 1008, 1009, 1013]. Again, all were deposited when still hot. There was also a 5mm thick deposit of industrial waste, which had been trampled into the ground, indicating the main area of access to the hearth during its operation.

Sub-Circular Platform

A small trench was placed across the western end of the platform to investigate its nature, evidence for human construction, and whether other features or deposits were associated with it (Fig. 2).

Platform

The trench was 7.5m by 3.75m and incorporated approximately one third of the platform's length. The platform was constructed from redeposited subsoil, 11.4m long and 6m wide, with a 6m by 6m wide patch of discoloured vegetation central to its surface, caused by lead contamination.

Pit

Within the area of the excavated platform lay a circular pit, 1.00m by 1.03m in diameter at the top and 0.37m deep [context 1043]. Its northern side and bottom were cut into bedrock. A succession of 4 different deposits [contexts 1041, 1048, 1054a–b] filled the pit. In the very centre of the pit bottom was a small deposit of white powdery material, which appears to be a lead compound [context 1054b]. This was covered by mixed industrial waste comprising burnt stones, charcoal, lead waste and slag [context 1054a]. Another industrial deposit was above this [context 1048], separated by a phase of slumping of the pit sides showing that it had been left open for a while. The fourth and final deposit comprised unburnt gritstones in a matrix of brown sandy-silt [context 1041]. In places the sides and bottoms of the pit are burnt, being turned pink, but this is variable suggesting that nothing was burnt *in situ* but that hot material was dumped into it.

There was no channel running into the pit, nor evidence for one leaving the hearth in the direction of the pit, suggesting that the pit was not a bole pit as defined by Kiernan & van der Noort (1992).

No dateable finds were recovered from any of the pit fills. Waste lead and slag was identical to that found in the fills of the hearth itself.

Earthfast Boulders

2.2m to the south-west of the hearth are two large gritstone boulders, which were interpreted as being earthfast during previous surveys (Fig. 2). A small trench was placed around these boulders to check this interpretation and investigate whether there was an archaeological origin for them associated with the lead hearth. After deturfing, the trench came down onto bedrock and undisturbed subsoil, which the boulders were securely and naturally within. This confirms that the boulders were earthfast. A lack of disturbance to the soil around them and only a background density of lead slag also demonstrate that they were not an integral element of the hearth's activities.

Artefacts

No artefacts were found during excavation except for lead waste, slag and burnt stones that comprised approximately 25kg of material. These were sent to Roger Doonan for analysis (see below).

Dating

The hearth was dated by GeoQuest Associates using archaeomagnetic techniques (full details in the archive report). This technique measures the alignment of the earth's magnetic field at the time stones were burnt. The field has altered alignment over time and when stones are subject to burning their position at that time is "fixed". Measuring this fixed alignment in relation to the field's current one enables the date of burning to be calculated. This technique only works if the stones have remained undisturbed since they were burnt. Enough stones lay undisturbed in the surface of the hearth to confidently gain a date for the last time the hearth was used. This occurred between AD 1430–1470 showing that the hearth was late medieval and therefore contemporary with Welbeck Abbey's holding of the land as part of their estate in the Upper Derwent.

Pyrometallurgical Finds by Roger Doonan

Excavations at Linch Clough, Derbyshire, have revealed evidence for a metallurgical process presumably related to the production of lead. In addition to specific pyrometallurgical features identified, an assemblage of burnt or vitrified finds were excavated from the site. Post-excavation analysis of these finds (further details in the archive report) was undertaken at the School of Conservation Sciences, University of Bournemouth. The post-excavation program included the physical examination of finds, the construction of a finds database, a program of microstructural and chemical analysis and the synthesis of a process model.

The Assemblage

Approximately 25kg of burnt or vitrified finds were recovered during excavation. It proved possible to divide the assemblage into seven main groups.

- Unburnt gritstone blocks
- Oxidized burnt gritstone blocks
- Reduced burnt gritstone blocks
- Oxidized burnt gritstone blocks (Slagged) (divided further by slag type green glassy or lead oxide)
- Reduced burnt gritstone blocks (Slagged) (divided further by slag type green glassy or lead oxide)
- Lead oxide/silicate conglomerate
- Lead metal spillage

Unburnt gritstone blocks

This category included any blocks or fragments of gritstone that showed no evidence of having been exposed to elevated temperatures nor the presence of adherent slag. It is impossible to be certain that these fragments were involved in the construction of the metallurgical hearth.

Oxidized burnt gritstone blocks

This category included any blocks or fragments of gritstone that exhibited evidence of having been exposed to elevated temperatures whilst in an oxidizing atmosphere. This was defined by the reddening of the gritstone resulting from the prevalence of ferrous ions favoured by heating.

Reduced burnt gritstone blocks

This category included any blocks or fragments of gritstone that exhibited evidence of having been exposed to elevated temperatures whilst in a reducing atmosphere. This was defined by the grey colour of the gritstone resulting from the prevalence of ferric ions favoured during heating.

Oxidized burnt gritstone blocks (Slagged) (divided further by slag type green glassy or lead oxide)

This category included any blocks or fragments of gritstone that exhibited evidence of having been exposed to elevated temperatures whilst in an oxidizing atmosphere (see above). In addition the presence of adherent slag (glassy green or white crust) was identified.

Reduced burnt gritstone blocks (Slagged) (divided further by slag type green glassy or lead oxide)

This category included any blocks or fragments of gritstone that exhibited evidence of having been exposed to elevated temperatures whilst in a reducing atmosphere (see above). In addition the presence of adherent slag (glassy green or white crust) was identified.

Lead oxide/silicate conglomerate

This category includes any dense nodules of lead oxide/silicate conglomerate. It is comprised predominantly of lead silicate with characteristic white crust although may include nodules of glassy slag.

Lead metal spillages

This category includes nodules of metallic lead, which have formed presumably in the hearth or spilled as the hearth has been emptied.

It is apparent that the metallurgical structure was constructed of siliceous gritstone typical of Linch Clough and the surrounding area. Such material is well suited for incorporation in metallurgical installations as the high silica content lends good refractory behaviour to any structure (*cf.* note below re silica inclusions). Two main "slag" types were noted on the gritstone blocks. The most common was a dark olive green thin glassy slag. This slag had the appearance of being of low viscosity and covered most burnt gritstone blocks. The second type of "slag" was a crystalline pale green lead silicate slag, frequently containing large metallic lead inclusions and being covered in a characteristic lead carbonate crust. The term "slag" is a convenient term to describe these materials although they may better be termed waste or process by-products. In most metallurgical processes that involve slagging technology the slag is formed to remove waste gangue materials (host rock) and to facilitate the coalescence of reduced metal as it is smelted from the ore. A property of a slag is that it should be immiscible (i.e. cannot be mixed) with the metal being smelted. Clearly the "slags" from Linch Clough are not intentional products to facilitate the economic extraction of lead from its ore, rather they may be seen as unintentional waste by-products that result when smelting conditions are less than optimal. The very high concentration of lead in these materials (>80wt%) is testament to their status as unintentional waste as opposed to worthless slag.

The kind of burning evident on the gritstone blocks is significant as it can be seen as an indicator of where in the hearth structure the blocks were situated. It is probable that the blocks covered in thin, green, glassy "slag" glaze and exhibiting evidence of being from an oxidizing environment were situated either above the main fuel stack or at the main channel along which air was induced. Reduced burnt blocks with green vitrified slag were most likely situated within the heart of the fuel stack where oxygen was scarcer. Gritstone blocks with adherent lead silicate slag accompanied by the characteristic white crust were most likely situated in a position where the galena/lead was running freely, most likely at the base of the fuel stack. Other significant observations were that many gritstone blocks exhibited defined facets suggesting they had been dressed prior to incorporation in the hearth structure. Unburnt gritstone blocks with adhering white crust were most likely situated high in the hearth structure, the white lead rich crust representing condensed lead fume.

Other meaningful observations included the fact that some gritstone blocks were slagged on more than one side suggesting that they were either re-used or that they were free standing blocks presumably to facilitate the entry of air. The possibility of re-use is an important issue considering the evidence for re-cutting of waste deposits within the hearth and channel.

Interpretation

The plumbiferous mineral veins that intersect much of the Peak District are intrusive solely within the Carboniferous Limestone and associated basaltic lavas. The general orientation of the major veins, or "rakes", is roughly east-west although this is subject to much local variation, especially in the Buxton area. Microstructural and chemical analysis has shown that the Limestone origin of the lead ore is beyond doubt since the frequent inclusion of Calcium Fluoride within the vitrified residues can only be equated with a Limestone origin (Ford and Rieuwerts 1983). The use of refractory gritstone for the hearth structure is indicative of a choice made by the smelters to use a material easily to-hand and resistant to prolonged episodes of heating.

SAMPLE ONE Context 1023 SFNO 1114 Lead silicate slag with carbonate crust (Plates 5 and 6)

The identification of Potassium Feldspar in some of the vitrified residues of Sample One suggests that the temperatures reached in the hearth were in the order of 1200C, at least momentarily and possibly for prolonged periods. The ubiquitous presence of the olive green glassy slag suggests that temperatures were at least 750C for prolonged periods of time. Such temperatures would not be expected in a simple bonfire and can thus be seen as in keeping with a technology which effectively managed the induction of air through the arrangement of a channel, either by force or harnessing prevailing winds.

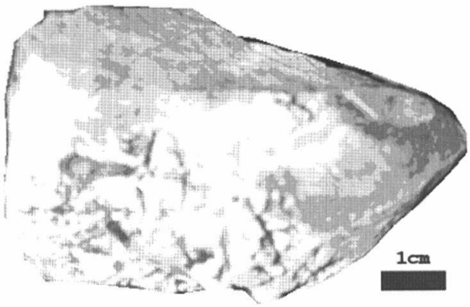

Plate 5: Macroscopic view of Sample One.

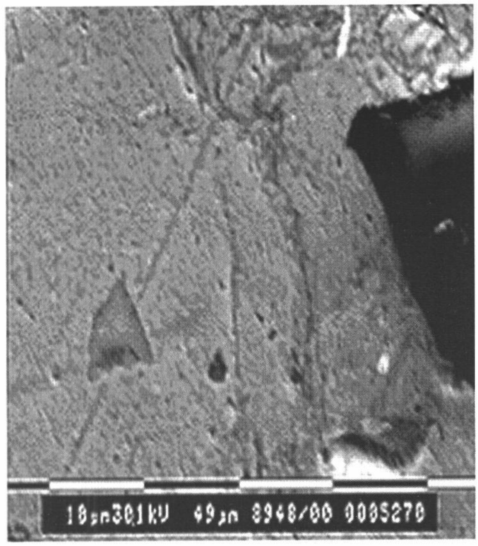

Plate 6: Inclusion of Galena within Sample One.

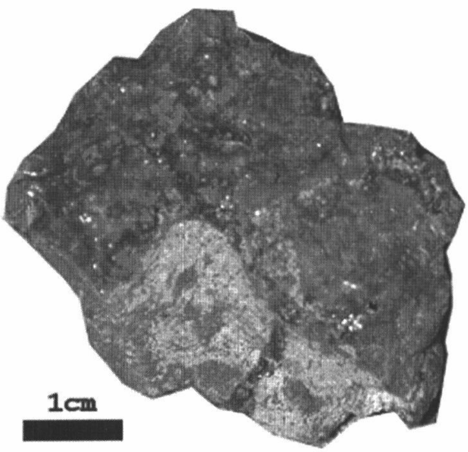

Plate 7: Macroscopic view of Sample Two.

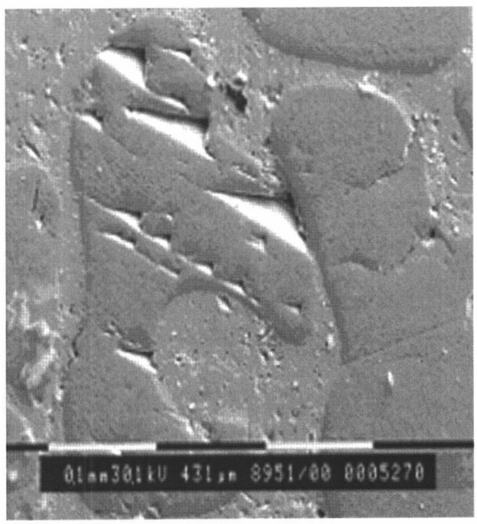

Plate 8: Electronmicrograph of lead "matte" showing decomposing Galena and intergrowth of metallic Pb and PbS.

The prevalence of oxidized burnt Gritstone suggests that a suitably oxidizing environment was easily obtained and sustained, essential for the smelting of Galena ores. The presence of Galena in the microscopic samples attests to its use as the main ore.

SAMPLE TWO Context 1006 SNFO 1026 (Plates 7 and 8)
Sample Two is interesting as it shows the formation of a lead "matte" an inter-metallic compound of mixed metal and sulphide. The micrograph clearly shows the degradation

of galena to metallic lead and liquid lead sulphide. The challenge to the smelter being that the liquid sulphide needs to be oxidized to metallic lead before it runs through the fuel stack and settles unconverted in the base of the hearth. The presence of specimens such as Sample One suggests that this was not uncommon and in excess would render the process inefficient, although resmelting would not be difficult.

Microscopic examination of metallic lead inclusions within lead oxide/silicate residues, e.g. Sample One, show that the presence of silica grains from the gritstone is ubiquitous. Although this can easily be removed upon remelting it may well offer a useful technique by which to differentiate pig lead and refined lead.

It should be noted clearly that analysis of the assemblage has found no evidence for a brick built structure or anything to suggest that the process was an intentional slagging one. The traditional bole smelting technique utilized in Derbyshire is often castigated as a primitive inefficient one. However, it seems its persistent utilization was not solely down to an inability to innovate or imagine other techniques. Salzman (1913) refers to a report of the Wexford mines in 1557 where a discussion of the best smelting technique is made. The Bole technique of the Derbyshire Bollars is condemned as costly and uncertain, needing a south-west wind that is steady. Whilst if a closed furnace is used then stamping and washing need more attention and labour costs are higher due to the pain of the extreme heat. Further the fuel concerns of a closed furnace create further difficulty. Clearly it is not so simple as seeing boles and furnaces on an evolutionary trajectory, rather they reflect local ways of working which themselves reflect the organization of labour. Salzman suggests (*ibid.*, 54) that boles were replaced at an early date by furnaces and forced draught using bellows often driven by water mills such as that in Devon in 1295 (quoting Salzman Pipe xx) whilst in Durham the foot pump was used in dry seasons (Page 1907, 349). The structure of the bole hearth has been a subject of serious debate and represents a category which, contentiously, has been seen to extend to *bayles* and to Devonshire *huttes* (Kiernan and Van de Noort 1992). The blocks of oxidized burnt gritstone covered with green glassy slag at Linch Clough can well be envisioned at the base of the fuelstack.

Discussion

It seems that the process best represented by the evidence from Linch Clough is that of the traditional Derbyshire Bole hearth. This is not to suggest that the process is simplistic or primitive. Indeed the dressing of ore, the siting of the bole, the preparation and construction of the hearth and fuel stack are all demanding tasks that have definite consequences for the efficient functioning of the Bole hearth.

The absence of a true slag at Linch Clough is further evidence that Bole smelting as opposed to closed furnace smelting was being practiced. Microstructural analysis of vitrified remains clearly shows that the process was capable of attaining high temperatures for extended periods of time. Although the Bole smelting process is often considered inefficient and unpredictable it is surprising that such a little amount of lead ore/intermediate was recovered during excavations. Indeed if a Bole is estimated to produce about 20cwt of lead each firing and the lead recovered as waste during excavation is conservatively estimated as 10% of total loss then it seems that the Bole smelting process could indeed be an extremely efficient process. Such interpretation can be seen as challenging existing models that promote a linear trajectory for technological evolution.

Charcoal by Rowena Gale

Charcoal was recovered from the hearth [contexts 1015, 1026], a dump on an adjacent platform [context 1023], a discrete deposit of charcoal in the linear channel [context 1046] and discrete dumps [contexts 1008, 1016, 1049 and 1057]. Identification was undertaken to indicate the type of fuel used in the process and to select suitable charcoal for radiocarbon dating.

Materials and methods

The charcoal was firm and well preserved, and mainly composed of fragments from large wood, although roundwood was also present. Charcoal fragments measuring >2mm in cross-section were considered for species identification. Samples 102, 103, 104, 107 and 109 and were subsampled prior to identification. The samples were prepared for examination using standard methods (Gale and Cutler 2000); charcoal fragments were supported in washed sand and examined using a Nikon Labophot-2 microscope at magnifications up to x400. The anatomical structures were matched to prepared reference slides.

When possible, the maturity of the wood was assessed (i.e. heartwood/sapwood), and stem diameters and the number of growth rings were recorded. It should be noted that measurements from charred material may be up to 40% less than the living wood.

Results

Where a genus is represented by a single species in the British flora this is named as the most likely origin of the wood, given the provenance and period, but it should be noted that it is rarely possible to name individual species from wood features, and exotic species of trees and shrubs were introduced to Britain from an early period (Godwin 1956; Mitchell 1974). Classification follows that of *Flora Europaea* (Tutin, Heywood *et al.*, 1964–80). The anatomical structure of the charcoal was consistent with the following taxa or groups of taxa:

Betulaceae. *Betula* spp., birch
Corylaceae. *Corylus avellana* L., hazel
Fagaceae. *Quercus* spp., oak

Sample Descriptions

Sample 103, Context 1015
Charcoal recovered from the western side of the hearth probably resulted from the final smelt. The deposit included lumps of oak (*Quercus* sp.) heartwood (up to 30 × 30 × 15mm) and a small quantity of hazel (*Corylus avellana*). Growth rates in the oak ranged from extremely slow to moderate or fast.

Sample 104, Context 1016
The sample included a large quantity of charcoal from a dump of industrial waste thrown onto the western side of the hearth (overlying *context 1015*), which probably resulted from digging lead out of the hearth after the final smelt to retrieve lead. Oak (*Quercus* sp.) heartwood predominated and included lumps up to 40 × 25 × 20mm. Oak growth was as described for sample 103. Intact segments from hazel (*Corylus avellana*) roundwood indicated the use of stems ranging from 10–25+mm (estimated from charred

measurements). Narrow growth rings suggested that the hazel stems were gathered from naturally growing bushes rather than coppice. In addition, a fragment of bracken (*Pteridium aquilinum*) or fern rachis was identified.

Samples 105 and 107, Context 1023
A deposit of charcoal on a platform [*context 1045*] immediately to the north of the hearth was interpreted as either a store of charcoal fuel or a dump of fuel debris. The charcoal from both samples consisted of comparatively small slivers of oak (*Quercus* sp.) heartwood and hazel (*Corylus avellana*). The morphology and size of the charcoal, which were considerably smaller than those recorded from the fuel debris from, for example, the hearth [*context 1015*], suggests that unless preservation in this context was extremely poor, the charcoal was unlikely to represent a fuel store.

Sample 108, Context 1026
A deposit of industrial waste including burnt stones and charcoal occurred within the northern side of the hearth [*context 1028*] and represented the *in situ* waste of smelting. Large lumps of oak (*Quercus* sp.) heartwood predominated over a small quantity of hazel (*Corylus avellana*) roundwood, the latter from 10–20mm in diameter. None of the hazel was fast grown and oak growth was as described for sample 103.

Sample 109, Context 1046
The sample consisted of a dump of pure charcoal found in the bottom of a linear channel [*context* 1053], which may have been a draft flue. The absence of industrial waste could infer that charcoal fuel was stored here prior to use. The charcoal was identified as mainly oak (*Quercus* sp.) heartwood but also included hazel (*Corylus avellana*) and birch (*Betula* sp.). Oak growth was as described for sample 103. There was no evidence to differentiate this material from other deposits of fuel at the site.

Sample 114, Context 1057
A discrete deposit of soil including charcoal occurred in one of the fills of a small pit [context 1055] to the south of the hearth. The purpose of the deposit was unclear. The charcoal was similar in character to that from the hearths and dumps described previously and included oak (*Quercus* sp.) heartwood and hazel (*Corylus avellana*) roundwood. Oak growth was as described for sample 103. There was no evidence from the charcoal to differentiate this material from other deposits of fuel debris at the site.

Environmental Evidence

The site was located on sandy soils with patches of silty clay overlying millstone grit bedrock. A group of Neolithic pits recently excavated by the Peak District National Park Authority's Archaeological Service (PDNPAAS) at Upper Derwent King's Tree lay within a few hundred metres of the site (Bevan 2003), from which charcoal deposits identified a range of trees and shrubs including oak (*Quercus* sp.), ash (*Fraxinus excelsior*), hawthorn/*Sorbus* group (Pomoideae), alder (*Alnus glutinosa*), birch (*Betula* sp.), bird cherry (*Prunus padus*), willow (*Salix* sp.) or poplar (*Populus* sp.) and elm (*Ulmus* sp.) (Gale 1999). It was evident from the charcoal that the area still supported stands of oak, hazel and birch in the medieval period; other species may also have persisted here but were not represented in the fuel deposits. There was no evidence to suggest the existence of woodland management, e.g. coppicing or pollarding, indeed most of the charcoal indicated the slow growth characteristic of harsh or exposed conditions. The lead-smelting site at Linch Clough may have been contemporary (and possibly responsible for?) the woodland clearance before the early 17th century (Bevan 1997).

Discussion

Charcoal analysis was carried out on samples from the hearths, [contexts 1015 and 1025], the platform [context 1023], the linear channel, [context 1046] and 3 discrete deposits [contexts 1008, 1016, 1049 and 1057]. Charcoal was abundant in all features, although slightly less so in contexts 1049 and 1057. It was clear that oak (*Quercus* sp.) heartwood was the preferred fuel and this seems to have been used in fairly large lumps — the deposits included pieces up to approximately 40 × 25 × 25mm. Most samples also included a small amount of hazel (*Corylus avellana*) roundwood, some of which included intact cross-sections with narrow growth rings. The hazel stems ranged in diameter from 7–20 + mm (charred measurements). Context 1046 also included birch (*Betula* sp.).

It was not possible to establish from the charcoal debris whether the lead-smelters used wood or charcoal fuel, although an absence of bark makes the latter most likely. Assuming this to be so, charcoal was produced from fairly wide oak stems or branches, which were predominantly heartwood. Most oak fragments demonstrated variable growth rates from extremely slow to moderate, with few including fast growth. It is impossible to know if the hazel and birch were converted to charcoal fuel or used as kindling wood. Given the low ratio of these to oak, it could be argued that kindling was the more likely, possibly used with other combustible herbaceous material such as dried bracken (as seen in context 1016, the dump of industrial waste) and grasses.

INTERPRETATION

The Hearth and its Landscape Context by Bill Bevan

Linch Clough

The Linch Clough hearth was a simple sub-rectangular shallow scoop in the sloping clough-side within which fuel and lead ore (and possibly slags also) were placed for firing. The correspondence of the hearth cut with the limits of scorching to the ground surface shows that the smelting operation was contained within this area. No direct evidence for an enclosing wall was identified, either as standing remains or as foundations, though numerous burnt gritstone blocks were found and the nature of some of the waste products suggest high temperatures difficult to achieve without using forced air and possibly some form of structure. There were dumps of industrial waste material, burnt stones, charcoal deposits, black and dark blue/green glassy slags, yellow-green lead "glaze" attached to stones, lead, and limestone.

Where the channel ran under the hearth it was either an open cut when in operation or had a simple stone covering which had since been dispersed. The lack of scorching and industrial debris in the areas of the channel outside of the hearth, its obvious south-western terminal and slight rise in height shows that the channel was not for tapping smelted lead as seen in lead hearths on Totley Bole Hill. It may have been a flue designed to get air into and underneath the charge. The deliberate continuation of the channel beyond both sides of the hearth would appear unnecessary to achieve this. It does appear as if the north-eastern end was not open to the air, quickly being buried under a significant depth of the rapidly rising northern clough-side. The semi-circular arrangement of stone, covering stone slab and eroded sections of channel immediately to the south-west of the hearth suggests that this was a specific location for activity associated with the hearth. This may have been where there was a foot bellows. Though the nearby watercourse would imply the use of water-power, the water level only becomes higher than the hearth approximately 200m upstream and around a bend in the stream. The stream would have been a good source of water for washing slags if this was a slag hearth.

The pit was initially thought to be a bole pit, as described by Kiernan and van der Noort (1992). Its location downslope of the hearth, burnt waste material fills and scorched sides, would all suggest its use as a container for collecting smelted lead. This appears not to be the case — there was no connecting channel between hearth and pit. It is unclear where the pit fits in the lead working processes identified on site, though it does appear to have contained burnt materials lifted out of the hearth and placed inside. Clearly, its role was connected with the platform it was dug into.

Medieval Lead Smelting Hearths

Little is known about the structure of lead smelting hearths except for a limited number of contemporary written descriptions and an even smaller number of excavated sites. Taken together, it seems obvious that there was no one standard design or construction for smelting hearths. Most researchers into medieval lead smelting take the contemporary written descriptions and compare them to known surviving sites.

Medieval lead smelting was small-scale. The total English and Welsh output in 1450, at the time of Linch Clough's use, was 400 tonnes (Homer 1991). Earlier, the lead industry had been concentrated mainly in Derbyshire and Somerset, with Derbyshire lead being exported via Boston & King's Lynn. By the time the Linch Clough hearth was being operated lead production was also expanding in the northern Pennines. Medieval lead was mainly used for roofing, coffins, cisterns, pipes, organ pipes and (after the introduction of moveable-type printing to Europe in 1440) for type metal (Tylecote 1986). Medieval slags had a high lead content, which gave them a distinctive appearance similar to black glass. The main technologies used during the 15th century for lead smelting were the wood-fuelled bole hearth for smelting ore and the charcoal-fuelled blackwork oven for resmelting the slags produced in bole hearths.

Boles were the main type of lead smelting hearth from at least the 12th century until the late 16th century in the three main English orefields, Derbyshire, Durham and the Malverns (Kiernan 1989, 40). The term "bole" does not appear in records before 1500 while the Old English "cost" occurs in the Peak District and is probably synonymous with bole. One hundred sites have been identified in the southern Pennines (Barnatt 1996). Most are found on the west facing slopes of the Eastern Moors though some are on the limestone plateau and others further east on the lower foothills.

In 1582 Robert Smith of Wirksworth and William Taylor of Alfreton described a bole as being situated on a hill, walled with stone, approximately 20 foot wide and requiring large amounts of timber and smaller wood for firing. In 1557 an author known as "T.B." described boles as out-dated, relying on the steady south-western wind for draught. The wind had to be constant for approximately 48 hours, and if it dropped or changed direction the amount of lead smelted would decrease dramatically so wasting the ore and fuel. Boles required large pieces of high quality ore to be effective, otherwise the percentage of the lead in the ores that could be retrieved was tiny. Good lead-bearing ores decreased during the 16th century so making the process less profitable (Blanchard 1981). The importance of the physical bole hearth is demonstrated in a small number of wills and inventories from the mid 16th century which specifically state that the foundation stones must be covered and maintained inbetween firings (Kiernan 1989, 41).

The blackwork oven was used to resmelt bole slags that contained a high quantity of lead, approximately 10% of the slag content. Only 10 have been definitely identified in the region (*ibid.*), most of which are closely associated with bole hearths.

A description of a blackwork oven by Thomas and John Babbington in 1537 implies that they were rough-built temporary structures (Kiernan 1989, 48). They are thought usually to be sited close to boles for convenience, though records show some to be close and others at a distance. Blackwork ovens were used in the Durham orefield since the 14th century and the earliest surviving record of one in Derbyshire is 1505 in Holmesfield. They are thought to have been low, circular stone structures in which washed bole slags were packed around with charcoal, sealed with a clay cover and powered by bellows, the most valuable equipment to produce the high temperatures required (*ibid.*). Experiments were made with blackwork ovens. It is recorded that blackwork ovens were used to smelt low quality ores in Weardale in 1460 and reputedly in Derbyshire in the mid 16th century though the higher quality of ores in Derbyshire leant themselves to be better smelted in boles. Small amounts of ore were added to the blackwork charge to improve the smelting process. In the 15th century in Nidderdale waterwheels were used for power, and in the 16th century coal was experimented with as a fuel. As the quality of lead ores decreased so the importance of blackwork ovens increased.

Excavated/Surveyed Lead Smelting Hearths in the Pennines

A small lead smelting complex has been reported at Totley Bole Hill (Kiernan & van de Noort 1992) though recent visits to this area have not resulted in the site being re-identified (Sarah Whitely *pers. comm.*). As published, the site comprises a bole hearth, blackwork oven, possible slag hearth and pond situated at approximately 325m OD on the west-facing side of a hill (Kiernan & van de Noort 1992). The bole is a rectangular, stone-walled, trench measuring approximately 7m by 3m, which fits well with Smith's description of 1582. Leading from either end and the downslope side are four channels, which converge into two then join to form an oval casting pit, 2m by 1.5m. This is situated approximately 20m downslope of the bole and is associated with fine grey slags. Fifty metres to the north of the bole is a blackwork oven, consisting of a 5m by 3m oval scoop with a few burnt perimeter stones on the surface. Two short channels lead to separate circular casting areas approximately 5m from the hearth. Substantial amounts of slags and charcoal are visible on the surface. Near to the bole hearth is a 3m diameter area of contaminated ground associated with charcoal and slags, some resembling slag hearth slags, apparently connected to the series of channels leading from the bole. This has been interpreted as a possible slag hearth, largely because its proximity to the bole suggests they could not have been contemporary (Kiernan & van de Noort 1992). The final feature is a pond, created by damning a spring, around which are pieces of washed slag.

A bole on Beeley Moor was very different in size and construction. It was built on the western side of a prehistoric triple cairn situated above a west-facing scarp (Radley 1969; Kiernan 1989). The hearth was a simple scoop, measuring approximately 1.15m by 0.76m, made in the western side of one of the cairns with no evidence for a wall identified. Layers of charcoal and slag were discovered.

At Gunnerside, the hearth was located on a south-west facing slope (Raistrick 1927). A 0.90m diameter circular depression set in puddled clay was enclosed within a 0.61m high and 1.52m diameter dry-stone wall. Openings at ground level in the west side of the wall would have allowed either wind to pass through or access for bellows. A short channel exited the hearth's eastern side to run to an oval casting pit. It has been interpreted variously as a bole (Raistrick 1927) and a blackwork oven (Blanchard 1981; Kiernan 1989).

Other Lead Working Sites in the Upper Derwent (Fig. 1)

A number of lead working sites have been discovered within the Upper Derwent. Earthworks of lead hearths have been surveyed in detail at Cold Side Oaks (Bevan 1998a; 1998b) and excavated at Howden Clough (Bevan 1997; Bevan 1999). The place-name "Lead Hill" is associated with deposits of lead slag (Bevan 1998a), while areas of vegetation-free ground may indicate other areas contaminated by lead (*ibid.*) and more recently scatters of lead slag and burnt stones have been identified in the draw-down zones of the reservoirs (Paul Ardron and Frank Robinson *pers. comm.*).

Cold Side Oaks

Cold Side Oaks is a much larger complex than Linch Clough, though it is the most similar in respect of surviving features and types of slag. It comprises three platforms, a lynchet, a leat, a quarry pit, a large area of heavy metal contaminated ground, and two patches of bare ground containing slag and charcoal fragments. The site is situated at a break of slope on the valley side with two of the platforms on steeper ground upslope of the remainder of the site. Each of the two platforms situated upslope is oval, 5 to 6m long, 3 to 4.5m wide, 0.4 to 0.5m high at the downslope side and contains charcoal fragments. One platform is situated near to a small valley side stream with which it is connected by a narrow leat running diagonally across the slope. The third platform is sub-rectangular, 8m long, 3m wide, 0.2m high at the downslope side and contains no visible charcoal suggesting that it was not used for burning charcoal. It may have had another industrial use or provided the foundations for a building.

The area of contaminated ground is oval, with the long axis running downslope, and is approximately 95m long by 43m wide and comprises the stunting and yellowing of grass, which is typical of grass growing within an area contaminated by heavy metals (Paul Ardron *pers. comm.*). Such contamination is commonly seen within the Peak District at the numerous lead working sites and rakes on the limestone plateau. Within the upslope end of this contaminated area are two adjacent patches of bare ground where contamination is presumably greater. One patch is rectangular and contains fragments of charcoal and a dark-coloured vitreous slag similar to that found at Linch Clough. The other patch is circular and again contains both slag fragments and charcoal. The regularity in the shape of both patches of bare ground and their close proximity to each other on the same contour suggests that specific activities, perhaps related to structures now removed, took place on these locations.

No precise date is known for the use of the site, except that it does not appear on any maps of the area available to the survey suggesting that it was abandoned before the earliest map.

Howden Clough

Howden Clough comprises a natural platform-like landslip that was used during the early 13th century for *melting* lead, possibly in a simple stone hearth, either to produce useable objects from lead pigs or to recycle broken/unwanted objects. Excavation suggests that it was used for a single lead working event (Bevan 1997; 1999). Parts of two pottery vessels, lead waste and burnt gritstones were discovered within deposits consisting of charcoal fragments, ash and sands. Activities at Howden Clough were probably opportunistic and short-lived (possibly a single event). Associated charcoal was abundant and included quantities of bark suggesting the use of wood fuel in favour of charcoal. Unless charcoal was imported to the site (on-site charcoal-making would have taken several days to complete) the use of wood would have been more appropriate for this, possibly, clandestine operation. Wood was gathered from birch (*Betula* sp.), hazel (*Corylus avellana*), hawthorn/*Sorbus* group (Pomoideae), *Prunus* (cherry or blackthorn) and, predominantly, oak (*Quercus* sp.) (Gale 1997).

Lead Hill

Waste, predominantly slag and furnace material, from lead smelting occurs in a discrete area of eroded ground on Lead Hill and is found scattered further downslope. However no earthworks of the furnace survive and its exact position is therefore unknown. The location of the furnace on such an exposed place above the edge forming the west side of Lead Hill shows that it was a medieval bole hearth.

Other sites

There are two small areas of exposed stony ground located on south-west facing slopes above the valley side (Bevan 1998a). These are suitable locations for bole hearths, though no slag or industrial waste has been identified. Since the reservoir bottoms were surveyed in 1996 (Sidebottom 1997), a number of small scatters of lead slag and lead-covered burnt stones have been found in the draw-down zone of the reservoirs. These suggest that a number of valley-bottom lead working sites were distributed throughout the valley, possibly similar to the Linch Clough hearth. More recently, evidence for iron smelting has been identified in the form of bloomery tap slag near Abbey Farm (Melissa Peet, this report) and near Hurst Clough.

Landscape Setting and Location in Relation to Lead Ore and Charcoal Sources

The hearth is at some distance from the nearest lead veins but located within an area recognized for its medieval woodlands. The ore itself and fuel are the two main resources for lead smelting. Many of the known lead smelting sites are situated away from the ore field, either to exploit wood sources for fuel or the updraught provided by gritstone scarps (Barnatt 1996). As a general principle the heavier ore was transported further distances than the fuel because its density made it relatively easier to carry by pack animal. Also, for Welbeck Abbey to conduct lead smelting it would be advantageous to set up hearths on its own estate to use its wood supplies (see below).

Lead ore or bole slags would have been transported to the hearth, either from lead rakes or from bole hearths. In the Peak District, lead veins are found across much of the limestone plateau and in some places continue under the shales bordering the plateau and the Derwent or Hope Valleys. The nearest sources to the Upper Derwent are found along the southern side of the Hope Valley between Mam Tor, Hope village and Bradwell Dale. These are approximately 11km away, and connected to the Upper Derwent by historical routeways recorded in the medieval period (Bevan 1998a; Dodd and Dodd 1980; Hey 1980).

The Upper Derwent valley was heavily wooded and the presence of charcoal burning platforms in Linch Clough show that this was a once wooded area in which charcoal fuel was made (Bevan 1998a). The slow growth rates evident in the growth rings of all three taxa suggests that the wood was gathered from natural rather than managed/coppiced woodland. It is likely that the charcoal was produced in the clough itself. There are several charcoal burning platforms on the north-facing side of Linch Clough (*ibid.*). Senior's survey of 1627 and later maps show light scrub and then no woodland cover in the clough (Potter 1808; Ordnance Survey 1880). This suggests that the charcoaling of woodland occurred before the early 17th century and consisted of the clear-felling of naturally grown timber rather than managed woodland. The presence of charcoal made from naturally grown wood in the 15th century lead hearth makes it very likely that this was contemporary with and to supply the lead hearth.

Another possible reason for locating the hearth in this particular clough is the wind tunnel effect generated when the wind is in the west. The wind blows straight down the clough and this may have been of adequate force and a sustained level to power the hearth in much the same way as positioning a hearth on top of a valley side.

Contemporary Land Ownership and Settlement

The mid 15th century date for the site associates it with Welbeck Abbey's ownership of land in the Upper Derwent (Bevan forthcoming). Part of the valley was granted to the Premonstratensian Abbey of Welbeck in Nottinghamshire by John, Earl of Mortaigne (later John, King of England) towards the end of the 12th century.

> "the pasture of Crookhill, the woods of Ashop up to Lockerbrook and from Lockerbrook up the valley of the Derwent and ascending up to Derwenthead."
>
> (Kerry 1893)

These comprise land west of the River Derwent from Crookhill to the source of the River Derwent, possibly all or most of Hope Woodlands parish, so incorporating Linch Clough. This was the first grant, later reconfirmed during the 13th century, and followed by 14th century grants of land east of the river. Welbeck seems to have rented out parcels to individual farmsteads and under these conditions Ronksley Farm was founded in the 13th century. In 1536 the monasteries and abbeys of England were dissolved by Henry VIII and their land was first controlled by the Crown before being turned over to private ownership.

Monasteries were greatly involved in industry during the medieval period due to the demands they had for resources at the monastery itself and on their granges. Monasteries had need of lead to furnish roofs, cisterns and water pipes of the large monastic buildings. They possibly also used lead for coffins for select members of the order such as abbots. Most operated iron or lead smelting hearths, usually using their own supplies of wood fuel and metal ores. The Abbey or tenants of Ronksley House may have operated the hearth.

The area was also within the Royal Forest of the Peak (Cox 1905). This is another piece of evidence that shows how land and woodland within the Royal Forest was used despite the supposed restrictions of Forest Law. During the medieval period wood within the Royal Forest was reserved for the King, however it is unclear whether this includes brushwood or just timber, and brushwood may or may not have been available to tenants. Offences included trespass, poaching deer and other game, damaging woods, enclosing land and constructing buildings. Either the use of wood or charcoal in the hearth was allowed in practice in this instance or the lead smelters were working illegally in regards of the Forest Law. However practice was often very different to Law with more activities allowed, sometimes on payment of a fine, than written down in Law. The whole of the Forest was eventually dissolved in 1674 due to mounting pressures from tenant farmers. Agricultural settlement in the Forest had already begun in the 13th century (*ibid.*). It was already significant in 1526 when a Royal Commission was set up to investigate matters, including the dangers to deer of the overgrazing of grass by cattle and sheep. Encroachment throughout the Forest led to the building of a wall in 1579 to demarcate and attempt preservation of the last remnants of the Royal Forest reserved for deer, which was equivalent to that of the present Peak Forest parish (Anderson and Shimwell 1981). The remainder of the Forest, including Hope Woodlands, Aston and Thornhill parishes, was still under Forest Law where deer were allowed to compete with livestock.

CONCLUSION

Here, at a remote moorland clough located at some distance from lead ore-bearing rocks, an industrial site was constructed and operated during the mid 15th century AD. Lead was smelted, with evidence that the site may have been returned to. Lead smelters would have walked up a clough-side track, away from the nearest settlements, to work here. The separation may have been for practical purposes, easy access to wood for fuel and to distance the poisonous fumes from houses and farms. However, this may also have been associated with a sense of removal from domestic life and a recognition of the risks to health involved. The hearth and activity of labour would have created a noisy, hot, dirty, smoky scene somewhat at odds with our perceptions of medieval rural life, and probably at variance with more regular routines of agricultural land-use in the clough. Men, for lead-smelters were probably male, sweated and breathed toxic fumes. They would have kept close attention to the smoke coming from the pyre to assess whether the smelt was progressing well, taking care with the footblast to get the burn right and not to get burnt. At the end, they would have broken into the fire debris in anticipation of finding lead pigs, and to discover whether their labour had been a success or not.

Archaeological excavation of the site has not only given a window into this local activity but has implications for furthering our understanding of the processes and technologies of late medieval lead smelting, both regionally and nationally. It appears to be a variation on the traditional Derbyshire bole. Significant differences exist between Linch Clough and what is known about boles. The Linch Clough hearth is in a valley bottom, used a forced draught and charcoal-fuel, while boles are found on hillsides, used wood fuel and the natural updraught. However, our knowledge of boles in the region is very imprecise. Documentary descriptions are sparse and only the two structures, at Totley and Beeley Moor, have been investigated in the Peak District. Beyond these differences, the lead-working process identified at Linch Clough appears consistent with how a bole would operate. It is unlikely that Linch Clough is an anomaly which deviates from the norm. The majority of other lead-working sites in the Upper Derwent are found in the valleys and exist alongside a typical hilltop bole location at Lead Hill. There is great variety between the three known valley-bottom earthwork sites — suggesting that different approaches to lead smelting were taken depending on local circumstances.

Linch Clough shows that we need to consider a wide variety in topographical location, construction technique and nature of surviving remains for medieval lead hearths in the region. This variety was based around a basic smelting process, with local smelters adopting and adapting slightly different techniques in relation to their industrial knowledge, land-ownership and the scale of operation. It also demonstrates that there may be many more valley sites throughout the region that have either been destroyed or still wait to be found. Both hearths at Howden and Linch Cloughs were subtle field monuments, which were identified from heavy metal contamination and vegetation erosion.

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