

THE DEVELOPMENT OF DEEP ECTON MINE, STAFFORDSHIRE, 1723-1760

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Abstract: This paper describes the Deep Ecton copper mine, one of Britain's richest mines in the 1760s to 1790s, in its earlier development phase, carried out by two companies of 'Adventurers' between 1723 and 1760. It brings together newly identified ore production figures with extracts from a recently executed detailed survey of the main easily accessible workings dating from this period. At this time the long Deep Ecton Sough as well as various shafts, the Dutchman Level and possibly the Apes Tor engine shaft and 34 fathom boat level, were created to facilitate access to the copper deposits and make them workable. By 1760 a massive pipe deposit, rich in ores, had been discovered at depth; the Fourth Duke of Devonshire chose not to renew the lease and from then onwards worked this mine in-house at great profit.

INTRODUCTION

The well known copper mines at Ecton, for a short period from the 1760s to 1790s and reaching an output peak in the 1780s, were one of the richest copper mines in Britain. During this time Deep Ecton pipe was worked to depth of about 330m (1090 feet) below its outcrop on the ridge-top, aided by engines, at least one boat level and a drainage sough. The Apes Tor 34 fathom boat level was one of the first employed in a mine and the steam-powered winding-engine introduced in the late 1780s was of the latest type, built by Boulton and Watt. Workings eventually reached a depth of just over 400m (1300 feet) but by this depth the pipe deposits had contracted in size.

Passages and engine chambers at Deep Ecton Level, where there is a sough driven from close to the River Manifold at the base of the hill, and some of those above, are still accessible. In contrast, everything below, extending about 310m (1020 feet) downwards, is now flooded. Parts of further rich workings can be entered, notably the Clayton Pipe and Waterbank Mine further south on the hill, which for much of their history were worked independently. While well-known as copper mines, lead was also produced in significant quantities at Ecton and zinc was also present. Overall accounts of the mines and their history have already been published (Robey and Porter 1972; Porter and Robey 2000).

Deep Ecton Pipe and nearby workings were in the possession of the Dukes of Devonshire and our understanding of the history of this mine is much enhanced by survival of detailed accounts from 1760 to the early 19th century, compiled at a period when the estate managed the mine in-hand. However, previously, the mine had been developed from 1723 onwards under lease to two successive companies of investors: It is this earlier period of working which is the main subject of the detailed assessment here.

Copper has been mined at Ecton since prehistory. Recently discovered evidence for Bronze Age working has already been reviewed (Barnatt and Thomas 1998), further detail on hammer stones published (Pickin 1999), and a regional and national context discussed (Barnatt 1999; Timberlake 2001). Similarly, exploitation of Deep Ecton Pipe and the nearby Dutchman Mine in the 1660s, first by the Earl of Devonshire from 1660 and then under lease by Jacob Mumma between 1665 and 1668, has been well documented (Robey and Porter 1972; Barnatt *et al.* 1997). It is known that working also took place earlier in the 17th century.

Until recently all that was known is that £200 pounds were spent on them by the Earl of Devonshire before the civil war started in 1642. Recent discovery of a marginal note in an estate account book for 1637-41, in the 1641 account, stating 'Copper oare in Wetton to be yearly enquired after', may suggest the mine was in the process of development when the war disrupted mining (Chatsworth Accounts AS/1010).

Moving forward in time, Hooson writing in 1747 stated that:

About forty Years ago, some Gentlemen came to a place called Ecton in Staffordshire, there for to venture at an old Work, which was drowned with Water, in hopes to get copper - but no People in the Neighbourhood could give any account when it was last wrought; they got Churn Pumps, Sweap Pumps and Forces and got at length to bare the Soles, and the Water proving very easy, (though they struck it at a very great height) they got great Profit; but in the Work it was admired by all Miners that saw it, what Blast-Holes had been bored, most a Yard or four Foot long, and two Inches or more Diameter, so that in those Days they used not such small holes as we do in these ... the report was that they were Dutchmen, others say Germans that was their Workmen.

Given that it is thought that Hooson took many years to write his work, this account may be reference to the work by Mumma in the 1660s. The exceptional shotholes described are almost certainly of this date (Barnatt *et al.* 1997), but the 1747 account is otherwise uncertainly interpreted - does it describe shotholes that were driven by the company noted or earlier shotholes discovered by them? Thus, there is a possibility that the mining venture described took place in the late 17th or early 18th century in an otherwise undocumented phase of activity. Whatever the exact date, the mining probably took place in the main Ecton Pipe or in Dutchman Mine. It may be memory of this venture, which while profitable had tried to work deeper in the flooded workings and presumably was relatively short lived as a result, that led to the driving of a sough started in 1723, the mine development which is the main topic of this paper.

After their heyday in the second half of the 18th century, the mines at Ecton continued in work through much of the 19th century with varying degrees of success; the history of the mine at these periods is well documented elsewhere (Robey and Porter 1972; Porter and Robey 2000).

Ongoing Research

This paper is one product of ongoing research into the Ecton Mines. Work on the prehistoric mining and on the 17th century use of powder has already been published (Barnatt and Thomas 1998; Barnatt *et al.* 1997). Further work has included a detailed metrical survey of the easily accessible Deep Ecton workings and Salt's Level above, as well as several of the smaller workings on the hill. This paper includes extracts from this survey; a detailed archaeological assessment of workings dating from 1760 onwards, set against the surviving estate accounts, will follow in due course. However, unfortunately underground work is currently stalled because of unavoidable access problems related to the long-term illness of Geoff Cox the mine owner. It had been hoped to complete the survey of Deep Ecton with a detailed assessment of the more technically-challenging and in parts unstable pipe workings and shaft both above Salt's Level to surface and below here in the main pipe and the nearby ladderway down to Deep Ecton. Similarly, plans to carry out surface metrical survey and archaeological excavations in potentially prehistoric workings are on hold. Detailed underground surveys of the complex accessible workings at Clayton/Chadwick Mines, Goodhope/Bag Mines and Waterbank Mine are for the future.

The metrical survey of Deep Ecton and Salts Levels, which included recording details of shotholes and evidence for various structures and fittings, has brought into sharper focus much of

what was known from previous inspection and the available historical information. In some cases it has forced radical re-interpretation. Combining the archaeological assessment with historical accounts, a detailed picture has now emerged of the date of virtually all accessible passages (Figure 2). To place the pre-1760s workings described below in detail in context, this is given in outline here and summarised in Table 1. The extensive passages at Deep Ecton Level, which were one of the main 18th century foci for removal of ore and water from pipe workings below, were gradually developed as extraction strategies changed.

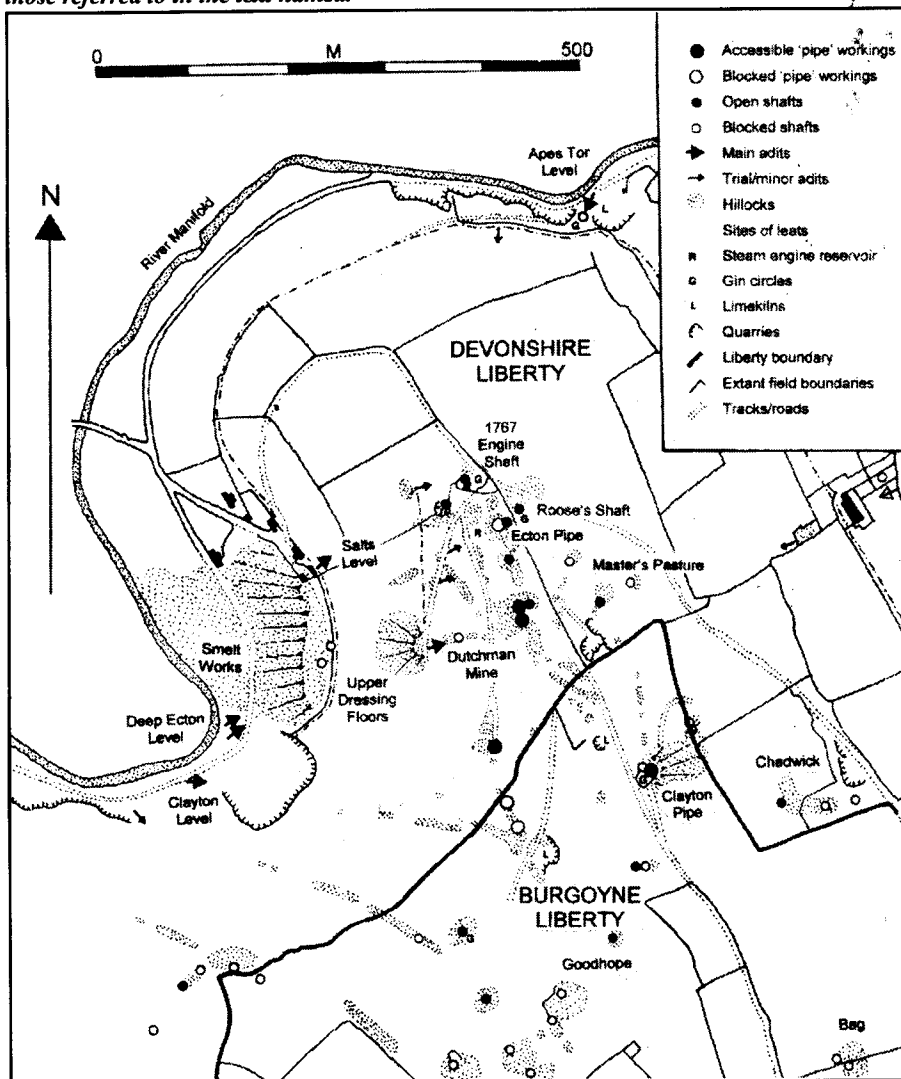
Pre 1760 - Work at this time concentrated, initially at least, on driving the sough used for draining the pipe below, workings here extending significantly below river level by the end of this period. There are also several accessible short trial workings off the sough and pipe, and two associated shafts. Details of all these workings are given below.

It was clear from the outset of survey that the main sough was not driven in 1774 as had previously been suggested (Robey and Porter 1972), but that this was the original 'Adventurers' sough started under the lease of 1723 (Barnatt *et al.* 1997). In 1774-75 there was an adjacent re-driving of the entrance section, presumably after a collapse, details of the creation of which are clearly identifiable in surviving six-weekly mine accounts. This realisation allowed a re-assessment of other workings in the mine, notably the upper Apes Tor level, situated at the same horizon as the Deep Ecton Sough; rather than being the 1723 sough (Robey and Porter 1972), it was driven in the early 1780s and again this activity can be found in the detailed accounts. These conclusions were arrived at independently at around the same time by Lindsey Porter, with the discovery of an unpublished diary entry by John Harper dating to 1767-70, which described the sough previously thought to be driven in 1774, and with the subsequent discovery by Rieuwerts of the original 1775 Clayton Sough lease which noted the position of the Deep Ecton Sough tail (Porter and Robey 2000).

Another radical discovery made during metrical survey was that a pre-1760 shaft existed that rises from the sough to the dressing floor to the south of, and at the same height as, Salts Level; this shaft indicates that this processing area existed well before the creation of the Level in the early 19th century and was not newly made then as has been previously thought (Robey and Porter 1972; Porter and Robey 2000). Ore was brought from the pipe along the sough as far as this shaft and then raised from here to surface.

A further possible important re-interpretation arises from problems interpreting the six-weekly accounts for the engine shaft at Apes Tor and a level at 34 fathoms (204ft/62m) below sough

Fig. 1. The location of Deep Ecton Mine and other adjacent mines on Ecton Hill, with those referred to in the text named.



level which ran from the Apes Tor shaft foot to the main pipe workings. These have been traditionally interpreted as having been created in the first half of the 1760s (Robey and Porter 1972, 21-24). Indeed the six-weekly accounts detail 'driving Apes Tor Levil' between March 1764 and June 1765, followed by making a turnhead, making a short upper level (presumably that still visible for running water raised up the shaft to the river), cutting the roof of the main level, and the widening of it and the Apes Tor engine shaft, the whole being finished and ready for use in March 1766. However, the distance driven in the Apes Tor 34 fathom level was only 316 feet (96m), which falls well short of the distance between the shaft and the pipeworkings. The problems of interpretation are compounded when shaft sinking entries are examined. There are entries for sinking one or more 'New Shaft' dating between September 1761 and December 1763. However, the earliest entries are named as at the 'Lead Sough' (Chadwick Mine) and sinking by the same named 'company' of miners reached a total depth of 121 feet (37m) in this 'New Shaft' by May 1762. The entries from June 1762 onwards, at a 'New Shaft' sunk by a succession of different 'companies', are not located and in this period a total of 191 feet (58m) of shaft(s) was sunk, which falls somewhat short of the known depth of the Apes Tor shaft. It is far from clear if these entries apply to:

- * A shaft at Chadwick Mine.
- * The shaft on the ridgetop later used for the Boulton and Watt engine to Deep Ecton.
- * An internal shaft within the mine at depth.
- * The Apes Tor shaft.

These problems raise the interesting possibility that the Apes Tor shaft and 34 fathom level were created before the inception of the Duke's accounting in 1760, presumably after large pipeworkings

were discovered by the 'Adventurers' well below sough level in the 1750s, and probably developed shortly after Roose described the mine in 1759 (see below). The driving in Apes Tor 34 fathom level in 1764-65 thus may represent the completion of a stalled project or the extension through the pipe workings of a level in operation by late 1760.

There is also a possibility that the 34 fathom level was designed as a boat level from the outset; this would make it a particularly early example, started in the same year as the well-known example at the Worsley Colliery in Manchester (Roberts 1981a/b). In March and May 1767 there are two six-weekly account entries for 'driving Boat Gate', which when combined give a total of 258 feet (79m), a distance that indicates widening of some sort rather than initial driving. These two entries are followed immediately by several for cutting the roof for a total of 405 feet (123m), completed in February 1768. In two of these entries the level being heightened is referred as the 'old boat gate'. If this level had only recently been created (1764-65), it seems unlikely that it would have been referred to in this way.

1760s and 70s - Several new developments occurred at this time concurrent with the progressive deepening of the pipeworkings below river level.

Whatever the date of the inception of the Apes Tor shaft and the 34 fathom level, from late 1765 at latest, and possibly from late 1763, ore and/or stone was being drawn on a regular basis, using horses 'at ye engine', from the Apes Tor shaft. Today, there is physical evidence showing a gin engine was installed at the shaft top on a restricted site well above the river, with room made for the gin race by cutting it into the cliff here. In 1767-68 the Apes Tor 34 fathom level was probably widened and re-instated as a boat level (rather than being newly created at this date - see above). From the mid 1760s, this became the second 18th century focal point for removal of ore, waste stone and water from pipe workings below. One mystery with this arrangement has always been how the extracted ore was taken from this inconvenient site to the dressing floors outside the sough entrance. While waste rock could be processed here in a large adjacent limekiln, there is no room for a dressing floor at the Apes Tor site. This problem has recently been solved with the discovery of an overgrown terraced trackway, the first part adjacent to the gin circle now quarried away, leading diagonally upslope and joining the course of a 1783-87 covered leat which leads to the Salts Level dressing floors. As it is now clear these floors are 18th century in date, the refined product from here then being dropped to river level for smelting and/or removal. This track would also have provided access to the gin for the horses used here.

A further departure in this period was the sinking of a new engine shaft from the hilltop, probably started in 1767, although possibly begun as early as 1761-62, and the driving of Pickering Level from the sough at river level to meet it, with a branch level to the other side of the shaft, both finished by 1770. This shaft was designed to draw ore from deep pipe workings up to sough level. It may be that the intention from the outset was to install a steam engine. Geisler writing in 1772 stated: 'Through this shaft a steam engine will convey the ore from the depths up to the adit' (Althin 1971), but

Table 1: Key dates in the development of Deep Ecton Mine in the period 1723-1780, from the formation of the first Company of Adventurers to early developments carried out *in-hand* for the Duke of Devonshire.

1723-39: First Company of Adventurers	1760 Onwards: In-hand for the Duke of Devonshire
1723 Deep Ecton Sough begun.	1764-66 Completion or extension of the Apes Tor 34 fathom Boat Level.
1731 Small intermittent amounts of copper ore start to be produced.	1767-68 34 fathom Boat Level widened.
1739-60: Second Company of Adventurers	1767-70 Sinking of New Engine Shaft on the hilltop to Deep Ecton Sough level and below.
1739-60 Probable sinking of Roose's shaft from the hilltop and Old Smithy Shaft from the dressing floors, and the driving of Dutchman Level.	1767-70 Driving of Pickering Gate to meet New Shaft at Deep Ecton Sough level.
1740 Probable completion of Deep Ecton Sough.	1769 Efford publishes a description of the mine.
1740 Significant amounts of ore produced from this date on.	1769 Probable conversion of Deep Ecton Sough to a second boat level.
1753 Rich ore deposits worked from this date onwards.	1769 Sinking of New Smithy Shaft from the dressing floors.
1755 Clayton Sough started.	1767-70 Harper's description of the mine.
1759 Exceptionally rich ore deposits start to be worked.	1772 Geisler's description of the mine.
1759 Mine assessed by John Roose.	1774-75 Re-driving of the entrance to Deep Ecton Sough
1759-60 Possible start of the Apes Tor Shaft and the 34 fathom Apes Tor Boat Level.	

this did not happen until the late 1780s and an exceptionally large horse gin at the shaft-top was used until this date.

A new second shaft linking the sough with dressing floors above, close to the first, was probably created in 1769. Careful inspection of the detailed accounts may suggest that the main Deep Ecton sough was also converted to a second boat level in February to June 1769. A total of up to 631 feet (192m) of the sough were modified and entries include 'widening of Suff Level for a boat gate', 'cutting room for boats to pass' and 'making room to load boats'. As already noted, in 1774-75 the entrance section to the sough had to be re-driven alongside the original course and an account entry, made immediately after its completion, notes 'Cutting room for a boat to unload'.

1780s - Two further radical changes in extraction strategies took place at this time. In 1783 a major change in the way water was extracted was implemented, with the installation of a large flop-jack engine in a purpose built underground chamber just north of the 1760s engine shaft. This new engine was operated by water brought from the river at Apes Tor in a new level driven for the purpose at the Deep Ecton Sough horizon between 1780-83. It pumped water up a large purpose-made shaft sunk deep into the mine, started in 1781 and known as 'Great Shaft'. This was laced and may also have contained a ladderway as well as being used for lowering equipment into workings below. Adjacent to this shaft a second chamber was created to hold a gin engine used in sinking the shaft and later as a capstan.

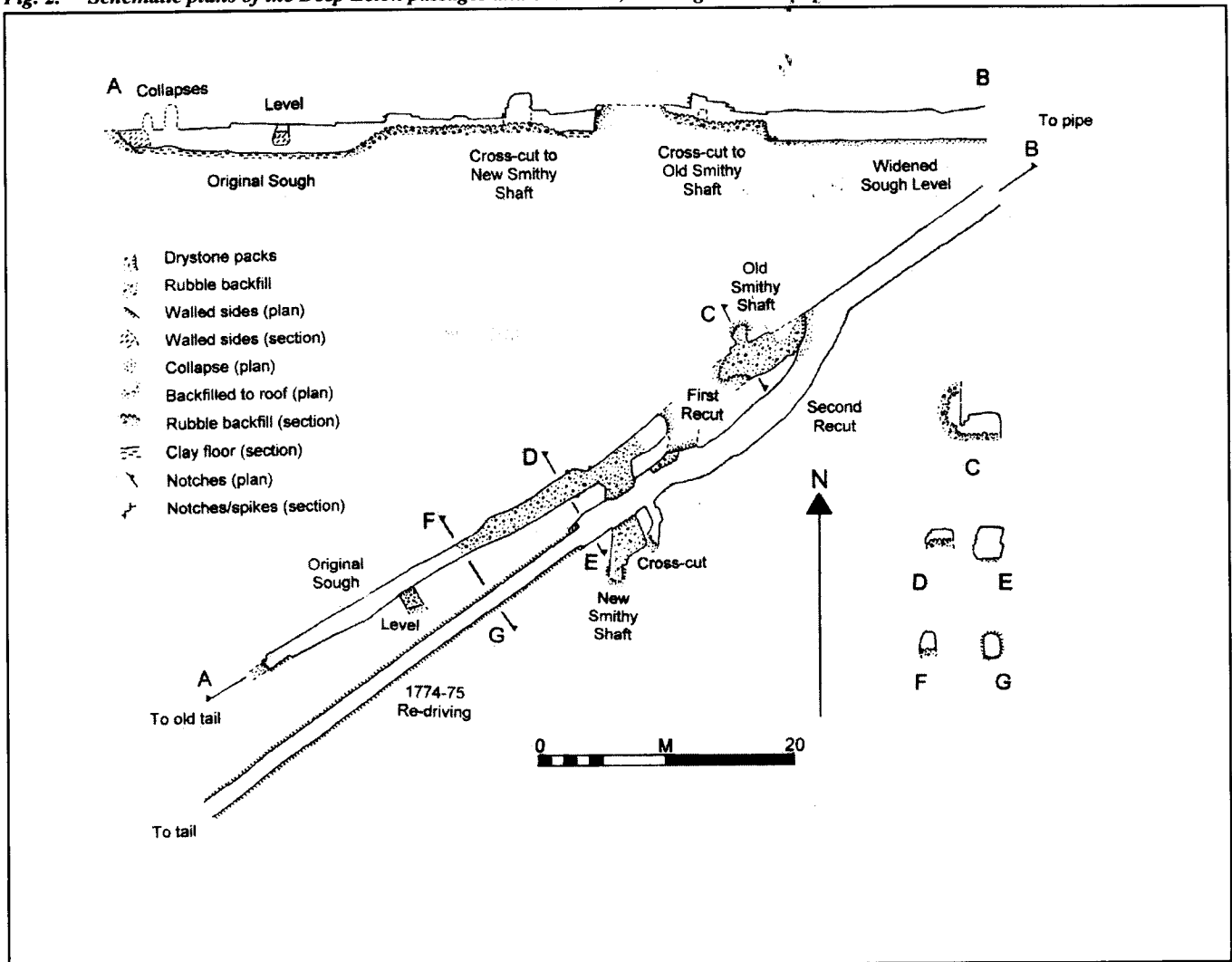
The second radical departure was the installation of a Boulton and Watt winding engine in 1788-89 at the 1760s engine shaft top, high above the mine. This was primarily used to bring ore to sough level, but was also later used for raising waste stone.

1790s - At the beginning of this decade the pipe failed at depth, and thus a series of trials higher in the mine were instigated. At river level, this included the long East Level, which was started at the end of 1793 and was driven until late in 1796, and a series of shorter contemporary levels running north-westwards from the gin chamber, with short raises to new workings above.

Nineteenth Century - Only minor trials took place at river level, including two short branches from East Level and another from the sough.

Salts Level - a little over 35m (115ft) above Deep Ecton Level, it was driven in 1804-07 to the main engine shaft, then turning from here to the main pipe and beyond; the last section, which was driven south-westwards and ran directly over the line of the pipe below, was an unsuccessful attempt to find rich upward continuations of the mineralisation. A ladderway to Deep Ecton Level was installed in an adjacent pre-existing working descending close to the main pipe. There is evidence for work of pre-1760 date around the pipe, indicated by particularly small shotholes in the pipeworkings intersected by Salts Level, as well as in the main pipe a little

Fig. 2. Schematic plans of the Deep Ecton passages and chambers, showing their development in the 18th and 19th centuries.



further down, in the small cross-cut to the top of the ladderway and in the ladderway itself. In contrast, further trial workings off Salts Level date to later in the 19th century.

THE PRE-1760 MINE - THE HISTORICAL ACCOUNTS Mine Leases

There are three mine leases surviving in Chatsworth House that are relevant to our understanding of the Deep Ecton Mine. The first is dated 1 Nov 1723 and was drawn up between William Second Duke of Devonshire and a group of 'Adventurers' who were granted the rights to mine at Ecton (Chatsworth Archives H/26/6). The named lessees were 'Baptist Trott Esquire of Mappleton, Thomas Sleigh of Stanshope, John Sleigh of Ashbourne, William Chaney, doctor of physick and Joseph Hayne, both of Derby, Hall Walton of Stanshope, William Wardle of Boosley and Samuel Lonford of Leek'. The lease was to run for 21 years and in return for the rights to mine the Duke was to receive a ninth share of the saleable mineral. In the event, the lease was surrendered in 1739, five years before it was to expire. The lease specified that the miners were:

to begin bringing up and perfect a Sough, Levell, Additt or Water gate, or Soughs Levells, additts or Watergates to be called Ecton Sough or soughs or Levell or Levells in and from such part or parts as they shall think most fit and proper and work and carry on the same in and thro' certain lands and grounds of the said Duke of Devonshire called or known by the name of Ecton alias Poysor Ecton or any [other] lands ground or soil of the said Duke...within the Lordship or Liberty of Wetton.

It also allowed 'Branch or Branches into or out of the said sough' and work in any 'veins or mines' it dewatered.

While this lease almost certainly relates to the main Deep Ecton Sough, its wording does not preclude other work on Ecton Hill, as for example at Dutchman Mine. The lease also included permission to drive into Burgoyne or other peoples lands, a clause presumably not indicating the lessees already had the permission of other landowners, who would no doubt have wanted a further share of any ore obtained; this may indeed have acted as a deterrent.

A second lease was signed on 12 Dec 1739, to run from 29th September 1739 for 21 years to Sept 1760 (Chatsworth Archives L/59/27 - draft of full agreement; L/76/12 - summary). This was drawn up between William Third Duke of Devonshire and 'John Gilbert Cooper of Locko in Derbyshire, together with Anne Chaney the widow of William Chaney, John Thompson of Ashbourne, apothecary, Samuel Longford of Leek, and Alexander Taylor of Buxton Hall'. This lease restates the first lease conditions and notes that the first company did:

begin to make and carry on a Sough or Levell in the said lands of the said late Duke but the same hath not been brought up and perfected as the said Lessees did propose and undertake.

The document then states that the old partners were willing to surrender the lease and that a new lease could thus be granted to John Gilbert Cooper and his partners to complete the sough into Ecton Hill following the same conditions of the first lease, again giving the Duke a ninth share, detailing that they also:

had or should hereafter have any liberty Power or Priviledge to mine search for or discover and Lead Oar Copper Oar and Calamy therein found or to be found and to build and make Coes and Sink Shafts with free ingress or egress and progress to bring and carry materials to and from the said sough or levell and mines and shafts doing as little damage

upon the surface of the soil...and also to bring and carry water to Buddle, Wash and Clean all such Lead and Copper Ore and Calamy.

This was all to be done at the lessees expense and they also had to keep the sough in good repair. It was stipulated that they must keep the mines in work, doing as little damage as possible, using 'methods for the best service and advantage' of the Duke, and that they must dress any ore obtained so that it was 'merchantable'.

This lease is particularly interesting in that it gives clear indication that mining activity was probably not planned to be confined to driving the sough at this time, but that other working such as shaft sinking could take place; it is known that both an engine shaft on the hilltop and Dutchman Level had been created sometime prior to 1760.

The third relevant lease was for the driving of Clayton Sough, the entrance of which was within the Duke of Devonshire's Liberty. This is dated 27th September 1755 and was between Thomas Gilbert of Cotton in Staffordshire and William Third Duke of Devonshire. Interestingly, it states that Thomas Gilbert had previously obtained a 30 year lease to work for lead and copper ore from Sir Roger Burgoyne dated 17th December 1753; this may indicate that no sough or level had been driven between the two properties as allowed for in the 1723 and 1739 Deep Ecton leases prior to the 1750s. While the driving of Clayton Sough is, outside the scope of the present paper, this document contains detail relevant to locating the Deep Ecton Sough. It gives:

free Liberty Licence and Authority to drive up a Sough or Drain thro' the sd lands of the said Duke to the said Mine called Claytons Mine at Ecton afd from the River or Brook called Manifold beginning at the distance of 88 yards before the foot or tail of another sough already carried up from that River to a Copper Mine in the said lands now in Lease from the said Duke to John Gilbert Cooper Esqr and others.

An accompanying rough plan confirms that the Deep Ecton Sough was approximately in the position of the present tail, while the stated 88 yards places it about 13 yards (12m) north of this, which is consistent with the position of the original sough tail (see below). The lease also allowed the miners to dress ore and erect buildings on the Duke's land at the sough mouth.

The surviving six weekly accounts dating from 1760 onwards (see below) show that Thomas Gilbert, together with his brother John the engineer who instigated the Duke of Bridgewater's underground canals at Worsley near Manchester in 1759, were in partnership with the Duke of Devonshire at Chadwick Mine on Ecton Hill from 1761 onwards; it may be that their work again started here in the 1750s but evidence of this remains elusive.

The Financial Accounts

A number of summary mine output accounts have recently been found by the author within the Chatsworth Archives, previously overlooked as they were in sundry general archives rather than those specific to Ecton. The data are within several series of estate accounts appertaining to 'Wetton and the Granges', one of the accounting subdivisions of the Devonshire holdings, and were mostly compiled by William and later Alexander Barker (Chatsworth Archives C/107, C/133, L/91/1/1, 1/91/1/2, L/91/1/3, L/95/28, AS/156, AS/1062,

AS/1063, AS/1064, AS/1065). Other data has been found in overall estate accounts kept by Geoffrey Heathcote the estate auditor (Chatsworth Archives L/91/3/2, L/91/3/3).

They provide an incomplete run of yearly outputs and the Duke's of Devonshire's ninth share of profits between 1723 and 1760 (Table 2). In some cases the overall total profit is not stated but this has been extrapolated in Table 2 from the ninth share. In one case where both are given, in 1740, it should be noted there is a slight discrepancy between the two. In all cases the accounting year starts from Lady Day and the table presented here shows figures rounded to the nearest hundredweight and penny. From 1755 onwards, the Duke's total share given includes a one twelfth share of Clayton Mine, but this probably does not distort the figures unduly as there was probably not significant output from here at this time as the sough was presumably still being driven. The figures in the accounts are specified as being for copper and as no separate entries are made for lead from Ecton, any such ore produced must have been in small quantities. It should also be noted that while the Duke's ninth share was all profit, the money going to the 'Adventurers' had to be offset against their outlay to obtain the copper.

The only entries for the period 1723-29 and 1732 in the accounts for Wetton are small quantities of lead ore and these are from the liberty as a whole rather than Ecton, suggesting that the miners at Ecton were concentrating on driving the sough and found no ore. In 1731 a small quantity of copper ore was obtained, the money from which was received from Mr Sleigh and Mr Thompson. While the former was one of the original partners, the latter was not. However, he is one of the partners in the 1739 lease; the implication is that he had bought shares by 1731. Similarly, money for ore obtained in 1737 was received from Mr Cooper, indicating he also had an interest in the mine two years before he became the main partner named in the new lease. Thus, by the time the 1739 lease was signed at least four of the five new partners had an interest in the original company; only John Thompson of Buxton Hall has no known prior interest.

The small quantities of ore obtained in 1731, 1735 and 1737 were perhaps from one or both of the two small cross-veins intersected by the sough where short levels were driven, or alternatively they were from elsewhere within the main pipe or from Dutchman Mine (see below). The lack of output for 1738 suggests that the driving of the sough by the first company of 'Adventurers' may have ceased at this date.

The mine started to show significant output from 1740 onwards, with a peak in 1741-42 and radically increasing output from 1753 to 1760. The exceptional output for 1759-60 no doubt reflects exploitation of the large pipe deposits well below sough level, which was presumably developed from 1753 onwards (or a little earlier, in the three years for which accounts have not been found), as they were already extensively mined when described by Roose in 1759 (see below). It is unclear if the early 1740s peak reflects:
* Completion of the sough.

Table 2: A Summary of the Chatsworth financial accounts for copper from the Ecton Mines, 1723 to 1761.

Year	The Ninth Share		Stated/Extrapolated Totals		Chatsworth Archive No.
	Tons	Value	Tons	Value	
First Lease					
1723	0	0	0	0	AS1156
1724	0	0	0	0	AS/156
1725	0	0	0	0	AS/156
1726	0	0	0	0	AS/156
1727	NK				
1728/29	0	0	0	0	AS/156 L/95/28
1730	NK				
1731	Usp	£5/00/00	3.65	£45/00/00	C/i 33
1732	0	0	0	0	C/133
1733	NK				
1734	NK				
1735	USp	£19/18/08	14.10	£179/06/00	C/133
1736	NL				
1737	USp	£18/1/00	USp	£166/19/00	C/133
1738	NL	0	0	0	C/133
Second Lease					
1739	NK				
1740	USp	£109/00/00	USp	£98 1/07/06	C/133
1741/42	USp	£893/08/00	USp	£8040/12/00	C/133
1743/44	USp	£200/04/00	USp	£180 1/16/00	L/9 1/1/1
1745	NK				
1746	USp	£66/05/01	74.6	£596/05/09	L/91/1/2
1747	NK				
1748	NK				
1749	USp	£79/10/04	119.6	£715/13/00	L/91/1/3
1750	NK				
1751	NK				
1752	NK				
1753	57.65	£698/10/09	518.2	£6286/16/09	L/91/03/02
1754	65.80	£643/12/03	592.00	£5792/10/03	L/91/03/02
1755	65.05	£567/12/09	585.65	£5108/14/09	L/91/03/02 C/107
1756	62.65	£562/18/00	563.80	£5066/02/02	L/91/03/02 C/107
1757	58.45	£528/07/11	525.90	£4755/1/03	L/91/03/02 AS/1062
1758	USp	£709/12/06	USp	£6386/12/06	L/91/03/02 AS/1063
1759	162.60	£1170/11/07	1490.15	£10539/04/03	L/91/03/03 AS/1064
1760	168.45	£1257/00/00	1515.90	£11313/00/00	L/91/03/03
1761	18.80	£126/13/07	USp	£1140/02/03	L/91/03/03 AS/1065
(For slimes only)					
NK = Not Known			Usp = Unspecified		UL = Unlisted

* Work in the pipe, perhaps with the sinking of the engine shaft.

* Work elsewhere, perhaps in Dutchman Mine (see below).

If the sough was completed in 1740, as seems most likely from these figures, this may suggest that the negotiation of the 1739 lease was a ploy by the 'Adventurers' to secure a favourable extension to the original lease, which was successfully executed shortly before the sough broke through to the pipeworkings. However, the abandonment of the sough by the first company can be alternatively explained as due to the difficulty in finding the main pipe, it having been driven on the wrong bearing (see below); the sinuous final stretch of the sough may have been driven after 1739 by the new company.

The figures given in Table 2 show that the price obtained for Ecton copper fluctuated over the period 1731 to 1760, fetching about £15 per ton at the beginning, with a steady drop in price

to about £6 per ton in 1749, and with something of a revival in 1753-57 when it fetched about £9-10 per ton. In this last period the accounts record that the Duke's copper went for smelting to Thomas Patton of the Warrington Copper Company (at Cheadle), whilst in 1759-60 the ore went to Charles Roe's Macclesfield Copper Company, fetching only about £7 per ton.

Roose's 1759 Mine Description and the Six-Weekly Accounts

Further documents relate to the taking over of the Deep Ecton Mine by the Fourth Duke in 1760, who chose not to renew the lease but work the mines in-hand (Chatsworth Archives, Ecton Mines, Box 1760-74).

The most detailed of these is an assessment of the mine about a year before the lease expired, undertaken for the Duke by John Roose and dated 8th September 1759. This records that there were 44 'workmen' (miners), 27 pumpers, 22 labourers and 12 carters, as well as blacksmiths and overseers, in employment. It is noted that 24 of the miners were 'employed in the bottom or forefield of the mine the other 20 are employed 12 fathoms above the Sough Levell wch is 45 fathoms from the bottom.' It was thought that 'there is probability of this work when the last 20 men are employed going down as low as the other, if this shall happen the mine may be very rich for a great many years.'

An accompanying sketch section with notes records that the top of the mine comprised 'an engine shaft sunk at the top of the hill 80 yards perpendicular' before much ore was Discovered'. At the base of this is shown a wider working slightly inclined from vertical, where it was noted 'Here the vein begun to bear a large quantity of copper and goes down to the sough level very irregular and is about 70 yards'. The section shows five 'floars or bundings where the men stand.' Below the sough the workings are shown somewhat more inclined from vertical to near the bottom, five more bundings are depicted and it was noted 'this part is worked under the sough 70 yards [66 yards according to the statement given above] and has born more regular than above the sough till it came within 15 yards of the bottom and is now cut horizontal about 42 yards for about 15 yards high and 8 yards wide.' It was also noted that the area 'about 50 yards above and below the sough has carried general about six yards square as near as I can guess' and that the 'present forefield of the Copper I apprehend to be about 60 yards North of the Engine shaft on the surface of the hill'.

As has been noted previously (Robey and Porter 1972, 85, note 34), the estimates of depth are overstated, as the sough is just over 100 yards below this part of the hilltop. Recent exploration shows the vertical shaft is 58m (63.5 yards) in depth, entering pipeworkings 42m (46 yards) down. From the base the twisting pipe descends steeply to Salts Level and the sough level below, the latter at about 107m (117 yards) from surface. Later drawn sections of the mine suggest the sole of the mine at this date was slightly above the 34 fathoms level (58m/64 yards) down from the sough, the depth of the Apes Tor 34 fathom boat gate.

Roose noted that '45 tuns of Copper sposed to be got out of the mine this last month at 15th June' was dressed. Extrapolating this figure, this gives an annual output for the mine at the time of about 540 tons; however, this is a gross underestimate, as indicated by the outputs of 1490 and 1515 tons in the accounts of 1759 and 1760.

A list of tools and equipment at the mine shows a lack of mechanisation to aid mining. As well as hand tools and sundry items, the only equipment was 31 hand barrows, 2 wheel barrows,

3 churn pumps, 4 launders, ropes at the turns, 48 kibbles (27 in use, 21 new), 2 barrels to carry water, 6 wagons for ye sough, 2 stone wagons, 36 knocking forms, 11 picking boards, 12 sieves, 6 riddles, 17 washing vats and a grinding stone at the 'Mound House'. Other buildings noted are 'ye workshop' and 'ye Recking {reckoning} House'. No gin engine is noted at this time, although one was presumably employed previously on the 'engine shaft'.

Another interesting surviving document from this period is a letter dated 10 May 1760 by Gilbert Cooper, objecting to the requested back-payment of cope at 4 pence per load on copper ore that the estate had forgotten to charge. The demand for this must have been galling, as a request for renewal of his lease had presumably been denied by this date. He states:

how could Copper ore and Callamy be subject to a dish when it is sold by weight', noting that only small quantities of lead ore were found at Ecton and these were measured by the dish but that 'after such a Number of Years working and so many hundred Tons of Copper got and carried away without any demand (except lead ore) seems a mistery I cannot comprehend, I acknowledge Ecton has been a very good mine but let me say that had I not undertaken it at great expence before I received any profit, the ore that has been rais'd and any likely to be rais'd might have remained in the bowels of the earth whilst the world endured.

It appears he had chosen to forget that the 1739 lease (in draft at least - L/59/27) clearly states that 'ffour pence for every load or nine dishes of Lead Ore and Copper Ore and Calamy' was to be paid.

The final direct strand of documentary evidence for the pre-1760 period is the surviving early detailed six-weekly financial accounts of the mines kept for the Dukes of Devonshire once the mine was taken in-hand in 1760. While much contained herein is beyond the scope of this paper, the entries occasionally give evidence for features which must pre-date 1760. However, it should be remembered that these accounts do not detail where all work took place, for it is only when paid work that did not produce ore by bargain that specific parts of the mine are normally entered by name, thus the record is far from complete.

The main feature we are sure existed and which can readily be identified is Deep Ecton Sough. However, an entry for February 1761 shows that 'Dutchman Level' also existed (contrary to the hypothesis previously presented before the accounts were studied - Barnatt *et al.* 1997, 40), for a dam was created here at this date. Other entries, for March and August/September 1761 note driving northwards a total of 8 yards (7.5m) from the foot of 'Dutchman Engine Shaft', a name suggesting a gin engine existed at this time or previously. That this mine continued in work for a while is indicated by further small scale driving at Dutchman taking place in Dec 1763-February 1764, 'carting' in May 1764 and 'baring an old gate' in February 1767. A level at Little Hom, which is thought to be the area of hillside above Dutchman Level, was driven for 10 yards (9m) in January 1762. Further minor work is recorded at Dutchman Mine in 1796 as part of a search for ore sources after the main pipe had failed at depth.

A number of other workings are also referred to in the accounts. These include Smithy Shaft and Starr Shaft. The former was recorded as being sunk between March and August 1769, at which date it reached a total depth of 30 yards

(27.5m). A 'level' from this, which was 8 yards long, was then driven to the 'suff level'. However, an earlier entry, for August 1763, notes repair at 'Smithy Shaft foot'. This apparent contradiction suggests there were two shafts here and the location of both the old and new is almost certainly near the inner end of the walled section of Deep Ecton Sough where two shafts were identified during survey (see below). As no sinkage for the old shaft is recorded in the detailed accounts, this was created before 1760.

Identifying the location of Starr Shaft, which again was sunk before 1760, is more problematic. It appears Starr was a name applied to a part of the mine rather than just a shaft. The following relevant entries occur:

- * September 1761 - 'Sludging sough at Star'.
- * June 1766 - Driving 4 yards (3.5m) 'at Upper Starr'.
- * December 1766 - Driving 4 yards (3.5m) 'at Starr'.
- * October 1768 to May 1769 - Driving a total of 30 yards (27.5m) 'out of Old Starr Shaft' 'towards New Shaft'.
- * September 1769 - 'Making a bunding at Starr Shaft'.
- * December 1769 - 'Widening and making round the Starr Shaft'.

A further summary account of ore raised from 1760 to 1774, made by Robert Shore, is also informative. For the period ending Christmas 1761 three sources of copper ore are given - 'from the bottom' which was by far the most productive, 'Upper Starr Shaft' and 'Lower Starr Shaft'. In the next year there are two sources 'from the bottom' and 'at the Starr', while after this all ore came from 'the Botham'.

The September 1761 entry probably links Starr with Deep Ecton Sough, as this was the only true sough in the mine at this date. It was presumably near 'New Shaft', as indicated by the 1768-69 entries, which was the engine shaft later used for the Boulton and Watt steam engine probably started in 1767 at latest, thus it seems Starr was at the heart of the mine. It is tempting to equate all these entries with the workings in the vicinity of the pipe from the sough level upwards that Roose noted as in work in 1759. There are several shafts near the pipe at sough level here but none of these fit with the accounts given above (see Figure 2 and Physical Evidence below); this forces the conclusion that the level driven in 1768-69 was not at sough level. It seems most likely that it was high above, as 'New Shaft' was probably not deep by this date. No obvious levels leave the pipe between sough level and the top of inclined pipeworkings which rise to a point about 49m above, intersected by the later Salts Level part way up, thus the unexplored level perhaps leaves the vertical pipe workings and shaft to surface at a point no more than about 50m down from surface (see below). The only shafts from surface which may equate with Starr Shaft are the main pre-1760 shaft noted by Roose (Barnatt et al 1997, shaft E7), which is about 63m (69 yards) from 'New Shaft', and a short shaft of unknown date nearby to the south-west, sunk into the pipe close to its outcrop (Barnatt et al. 1997, shaft E8) at a similar distance from 'New Shaft'. While the pipe twists about as it descends, it seems unlikely that it ever comes within 30 yards (27.5m) of 'New Shaft', perhaps suggesting the 1768-69 level was never finished or that it included pre-existing workings along its length. Alternatively, Starr Shaft may be an internal shaft that is not currently accessible.

Obscure references in the six-weekly accounts include named workings at 'Owlneft' and 'Noahs Ark'. The forefield of 'Owlneft' was driven forward by 6 yards (5.5m) in August to November 1761. In May 1764 driving 2 yards (2m) towards 'Owlneft' was

also recorded, suggesting it was part of a larger set of workings rather than an isolated mine. Driving for 4 yards (3.5m) took place in 'Noahs Ark' in February 1762. Neither of these workings has been positively identified on or under the ground.

Later Descriptions of the Pre 1760 Sough

There are three first-hand descriptions of the sough and its intersection with the pipe that date to the late 1760s and early 1770s. While the sough and working arrangements may have been modified subsequent to 1760, the accounts effectively describe this part of the mine before the radical restructuring of the 1780s and thus give insights into the general character of earlier workings.

Efford (1769) describes the sough to the pipe:

To take a view of this stupendous Copper-Mine, you must enter an Adit at the base of the hill by the river Dove [Manifold], and proceed about 400 yards [366m], almost in a direct line. At your entrance, about sixty yards, tis four feet and a half high, walled up on each side with good stone masonry; but afterwards it varies in height, and rises in some places to six feet. When you arrive at the centre, there is a spacious lodgement of timber, for landing and receiving the Ore from below, which is drawn up by a man at a winch, who generally works naked, and is put into four-wheeled wagons that will hold about a ton and a half each. These wagons have cast brass wheels, and are run in grooves thro' the Adit, by boys from 12 to 14 years of age, with great facility. When on the lodgement, you behold a large hollow over your head, at least 250 yards [228m] high, by the sides of which there is a passage to the summit, but dangerous to attempt, as the timberworks seem in a decayed state.

The unpublished account by Harper, dated to somewhere in the period 1767-70, is a hand written draft with additions made (given here in parenthesis). An accompanying sketch plan confirms it is Deep Ecton Level that is being described, but that Harper mis-orientated himself and thus indicates directions incorrectly. The part describing the sough states:

Went in ye mouth of the sough (which is abt 20 feet above Surface of ye Manifold) abt 60 yards [55m] - boarded, about 160 yards [145m] water carr: straight line southwards [north-east] then abt 70 yards [65m] further on boarded passage winding first to ye east [north-west] - then south [north-east] again. Then come to a large (circular) opening (or vault or chamber) abt 30 y[ar]ds [27.5m] wide ye sides (and roof) of it all stone and spar ... The floor of this opening or chamber is rock at ye southern [north-east] end (there is) an opening (or trap door) down (into) another opening or vault or chamber abt 80 yards [73m] below ye first.

Harper also notes the Apes Tor 34 fathom boat level, stating:

From ye 3rd floor [bundling] a sough or water carr for boats, which goes eastwards [north-west] to a place where ye Engine (horse engine) is worked - which is abt 50 fathoms [90m] high ... from ye sough up to ye engine.

The depth of this level is overstated - in the first draft he states about 45 fathoms [80m], which is somewhat nearer to the mark, the engine being above river level at about 40 fathoms [70m], but this was crossed out and increased.

In 1772 Geisler wrote the following account:

At the foot of the mountain, at a depth of 60-70 fathoms [110-128m], an adit has been made, where water has been led in, and transport into the open is arranged in long and narrow boat, but also in carts with 4 small iron wheels with grooves, guided between sleepers made

of 5 inch squared logs. After going with a gosse [boy?] on the water into the adit, which was done quickly and comfortably for 150 fathoms [274m], one would then walk into a wide room, created by ore being removed from there as well as higher up and still [in work] 80 fathoms [146m] under the adit.

This last account appears to confirm the suggestion that Deep Ecton Sough was in use as a boat level at this date. While it has previously been assumed that Geisler was referring to the 34 fathom boat gate, the account taken literally does not easily read to suggest this and more importantly the depths given are at odds with this interpretation. While the stated depth of 60-70 fathoms (110-128m) cannot be equated with a depth from river level downwards, it fits well with a height above sough level to the ridgetop above, the pre-1760 shaft from surface starts at about 109m above the sough and the ridge rises higher to the south. The reference to both 'boats' and 'carts' is clarified by Harper's account, which shows the inner sinuous section of the sough was boarded while the section from here to the Smithy Shafts was a 'water carr'. If this interpretation is correct, then it appears that Efford either omitted to mention the boats, or more probably that the level was converted to an underground canal shortly after his visit; the latter is consistent with the six-weekly account entries for the widening of the sough for a boat gate between February and June 1769.

THE PRE-1760 MINE - THE PHYSICAL EVIDENCE

The Ecton Pipe

At river level, where intersected by the sough, the worked pipe is a very-irregular near-vertical void, measuring 7.5x7.0m across (Figure 3), with a deep blue pool filling workings that are over 300m deep (Plate 1). Nineteenth century mine plans and sections indicate that the rich pipe workings below extended roughly northwards and north-eastwards from those visible at sough level. Here and in many other parts of the accessible pipe there are few indicators given by shotholes of the date of workings (following the size typology published for the mine - Barnatt *et al.* 1997). Presumably much of the work was in relatively soft mineral where powder was rarely needed. Surprisingly there are no notches to the north side of the main pipe at floor level to indicate the presence of a large bunding; Efford and Harper appear to record the presence of such a structure here. Presumably some pre-1760s hauling to sough level took place at the adjacent striking house shaft to the south-west (see Sough below) and possibly at a further bunding to the east. Here, there is the top of a branch pipeworking, which continues downwards and may well enter the main working a short distance below water level. There are two massive stemples surviving at sough level that supported a bunding, one plank of which also survives. To the west of the main pipe a second short branch working rises steeply and soon re-enters the main void; this has relatively large shotholes of 29-30mm diameter which may well indicate it is a relatively late trial.

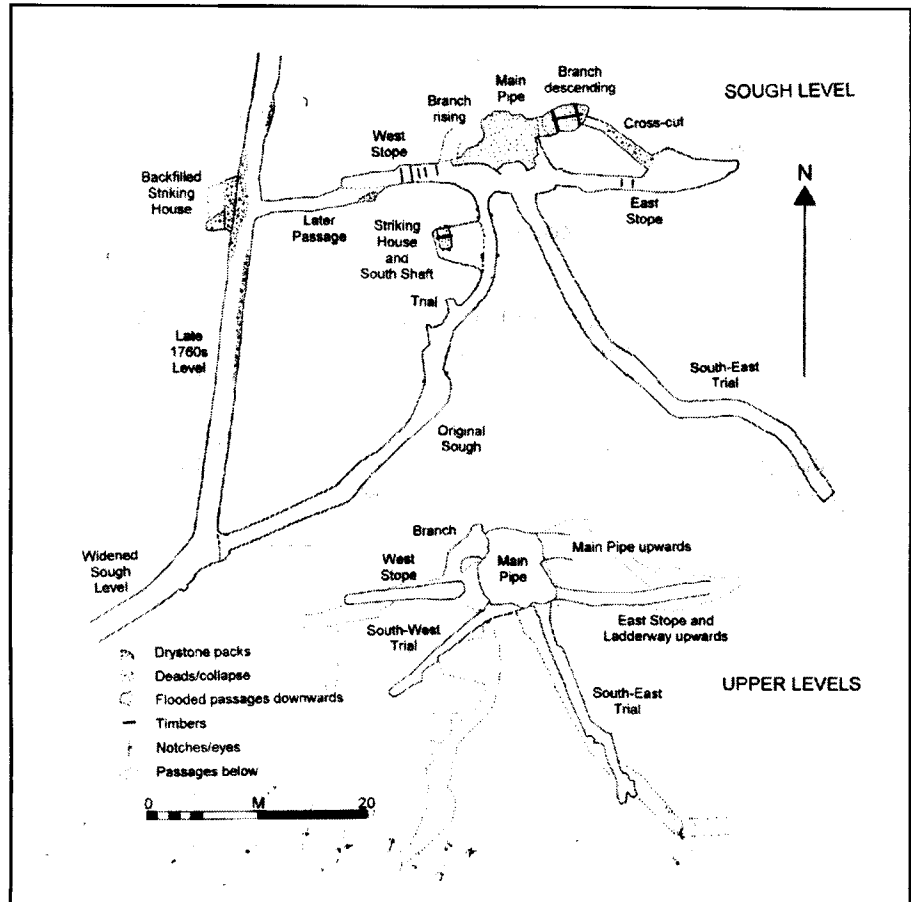


Fig. 3. Detailed extract from the Deep Ecton Survey, showing a plan of the pipeworkings and adjacent levels at and just above river level.

A short distance above the vertical section of pipe at river level, it continues upwards at a steep angle with waste material on the floor (Plate 2); running ENE to a point a little below Salt's Level. Here again there is a short vertical section, with a branch side working at the base running east that has large shotholes and is a late trial. There is a second small branch pipe in the roof 4m to the west, rising vertically, the top of which is intersected by the south-west trial level extension of Salts Level driven along the line of the main pipe below it. A further pipe working to the south is linked by a 10m long cross-cut from Salts Level; this also descends steeply to Deep Ecton Level and is more stope-like near the bottom (see below). In places there are short links to the main pipe where the two workings virtually intersect. It was utilised as a ladderway from the early 19th century and perhaps previously.

Above Salts Level the main pipe continues very steeply upwards to the north-east, twisting more to the east to reach the base of the pre 1760 shaft noted by Roose, with a large rising branch working to one side. The ladderway pipe, which looks to be small above Salts Level, has not been assessed.

Exactly where amongst all these workings the miners were active in 1759, noted by Roose as employing five bundings, is not clear. His statement that they were at work 12 fathoms (22m) above the sough places some of this work about 15m below Salts Level. Given the wording of the account and the date of working, well after the main pipe had been intersected at river level below, it seems likely that the mining in 1759 was



Plate 1. The main Ecton Pipe at sough level, looking into the flooded workings below.

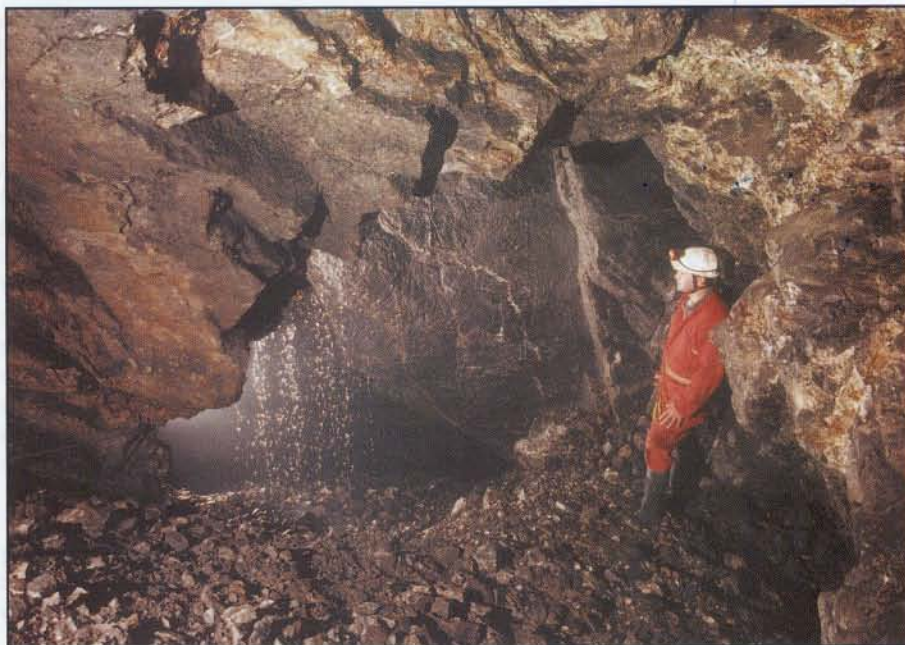


Plate 2. The steeply inclined section of Ecton Pipe between Salts Level above and the sough level below.



Plate 3. Deep Ecton Sough, with the 1774 re-driving to the left and the blocked original course to the right.

not in the main pipe but in one or more of the branches, perhaps that later used as a ladderway. This seems particularly likely with the workings noted as 12m below Salts Level, as there are no other branch pipes known at this horizon.

Above the base of the pre-1760 shaft the pipe workings remain unexplored in any detail, but preliminary exploration of the shaft was undertaken by Garth Thomas and Bob Dearman in the 1990s (Barnatt *et al.* 1997). For the first 16m upwards the shaft appears to be sunk through the pipeworking and there are unexplored passages to the sides including one that rises steeply. The top 42m of the shaft has been sunk through solid limestone and the pipe outcrops just over 20m to the south-west of the shaft top. At surface the shaft is surrounded by a now badly robbed hillock and at the upslope side there are the possible remains of a disturbed gin circle.

Stopes and Trials

Running both east and west out of the main pipe at Deep Ecton Level there is a stope-like working (Figure 3). To the west this runs for 11m and is up to 7.5m high, where it is intersected at sough level by a low offset cross-cut that has 33-36mm diameter shotholes suggesting this is a late passage. There are shotholes of various sizes in the stope itself, ranging from 25 to 36mm in diameter, probably indicating periodic working and reworking. A series of slots and notches demonstrate the presence of a working platform 3m above sough level. Beyond the low section, the passage intersects the late 1760s level to the main engine shaft and has again been worked upwards from the late 18th century onwards. At the intersection there is also a backfilled striking house chamber for drawing ore from below which was probably created in 1786.

The east stope runs for 18.5m at sough level, and after a low section with holes upwards, there is a tall working, with the ladderway to Salts Level crossing it high above. One large surviving stemple lower down, 5m above the floor, is probably the remains of a working platform. A low section at the sough-level entrance to the stope has shotholes of 32-33mm diameter, probably indicating a late driving to link the stope to the main pipe here, but in the areas beyond most shotholes are in the range 22-24mm, strongly suggesting an earlier 18th century date. Running north-westwards from the eastern stope at floor level there is a small cross-cut, partly backfilled, linking to the eastern branch pipe. This has small shotholes of 22-24mm diameter, again indicating it is probably of earlier 18th century date.

In parts, both stopes have had false floors and there are visible wooden stemples. They have clearly also been worked downwards, one floor sounds distinctly hollow, the stability of these floors is unknown and they should be treated with care.

Three trial levels branch from the main pipe at or slightly above river level (Figure 3). At sough level one heads sinuously for 42m to the south-east. This has shotholes of 25-28mm in diameter and thus is likely to be of 18th or early 19th century date, but being more precise than this has not been possible. It is not clearly identifiable in the detailed accounts from 1760 onwards. However, the possibility that it dates from this period cannot be discounted and several obscurely interpreted references to driving trials in the 1790s could apply. Alternatively it may date to years in the early 19th century for which detailed accounts do not survive.

The two other trials are driven from a slightly higher level, which would suggest they pre-date the sough, for once this was driven

this would be the obvious horizon from which to drive. Both levels have shotholes that are 21-24mm in diameter, also indicating an early date. That to the south-east is 4.5m above sough level and follows the same line as the trial below. It is 20m long, and doglegs and rises partway along. The upper trial to the south-west is only 2.0m above sough level and is 13.0m long. Near its entrance are two pairs of matching slots and notches, placed one above the other as if the passage had been closed with a wooden partition or door, although the reasons for this are obscure; perhaps it was utilised for storage of equipment.

The Sough

Much of the present sough passage, which is 340m long from its tail to the main pipe at river level, has been significantly widened and slightly deepened after 1760. However, a sinuous stretch adjacent to the pipe and a further abandoned section near the original collapsed tail may be substantially original. When first driven the sough, being straight at the outer end rather than angled, was something like 5m shorter, at about 335m long.

The sinuous stretch at the inner end (Figure 3), which is 44m long, is generally not as wide or as high as the main section of sough, being in parts as narrow as 0.9m and generally 1.7m high. This indicates the likelihood of early date, left relatively untouched since the change of focus in the late 1760s, with the driving of passages to the new engine shaft; the only exception is one aborted trial into mineralisation on the north side with a large 19th century shothole. This said, there are indications of early modification to the passage suggested by changes in shothole size and direction. On much of the south-east side of the passage and in the roof the shotholes are in the 21-23mm diameter range and are generally driven towards the pipe. In contrast, much of the other side has shotholes of 25-27mm diameter, driven the other way. This relationship suggests the passage has been widened somewhat. A short central section of the passage has the larger shotholes driven towards the pipe on both sides of the passage.

The sinuous nature of this stretch of sough stands in strong contrast with the outer straight section. This characteristic cannot be explained by later widening of the outer part and two potential interpretations need consideration:

- * The sough proper intercepted a pre-existing trial level and thus significantly shortened the distance to drive.
- * As the sinuous pipe was approached there was uncertainty as to its position and thus orientation was changed several times, in part taking advantage of north/south weaknesses in the steep bedding that were sometimes followed.

As noted above, the smallest shotholes run towards the pipe, suggesting the latter explanation may be appropriate, although this argument is not conclusive. In its favour, the odds of hitting a pre-existing trial at exactly the right place and level are not high, particularly as accurate surveying down the sinuous pipe workings prior to sough drivage must have been difficult.

At just over 2m from the pipe end of the sough, there is a small striking house measuring 4.5x4.0m, with a floor 0.3m above the sough floor and a shaft descending from the far side. This striking house is likely to be an original feature as it has been carefully shaped with shotholes of 22-23mm diameter. The

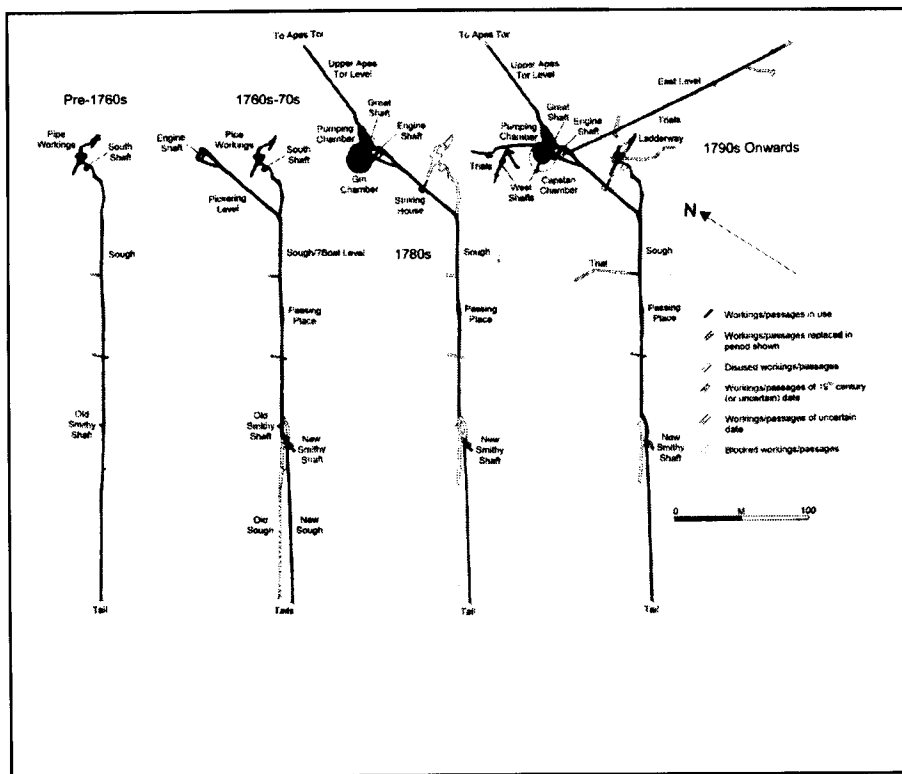


Fig. 4. Detailed extract from the Deep Ecton Survey, showing a plan and section of the intact section of original 1723 sough at the inner end of the arched 1774 entrance level.

flooded rectangular shaft measures 1.8x1.1m across and is of unknown depth. There is a cross beam just over 1m down which has trapped collapsed timberwork, and there are notches for a matching beam above, suggesting the shaft was laced, with a larger section for hauling and a narrow ladderway to the north where there are two surviving iron hooks one above the other. At the two ends of the shaft, at floor level, are two further pairs of matching notches, suggesting the original presence of a timber floor over the shaft with trap doors and/or the frame for a hand stowe. In the sough to either end of the striking house there are further complex arrangements of notches, possibly suggesting a timber floor extended over the sough here and that the sough was crossed by two partitions. On the south wall of the striking house are carefully-made initials 'JB', in an 18th century style, pecked with the point of a pick.

Two short trials, following minor mineralisation, branch from the sough in its central widened section. The first, about 183m from the original tail has short levels driven to either side, that to the north-west 8.0m long, the other to the south-east only 2.5m long. Both have shotholes that are 23-26mm in diameter, which suggests they are 18th century in date and they may pre-date 1760, perhaps created as the sough progressed into the hillside. A further 60m into the sough a second trial branches to the north-west. The first 6.0m of this has shotholes of comparable size on one wall and is probably of similar date. However, in this case the level was widened and extended in the 1880s and this section has much larger shotholes. That one of these three levels post-dates 1760 is indicated by a reference in the detailed accounts for 1763, where it is noted that payment for the creation of a 'cross cut out of sough' driven for 12 feet (3.5m); this is difficult to place unless it refers to one of these trial levels and payment must have been made because it produced little ore.

Near the tail of the sough, from the inner end of the 1774

re-driving and a still later short extension (see below), part of the original sough has survived (Figure 4). Here 48m of earlier passage is mostly accessible, although one short section is blocked and other parts have been partly backfilled. The first section at the north-east end is accessible through a partly-collapsed drystone wall built to block it (Plate 3). Here there is a 3m wide passage, partly backfilled with rubble, that was still initially in use after the 1774 re-driving; this area is now dangerously unstable and should not be entered. The passage may well have been widened as with the sough further north-east, and/or it was a small chamber associated with the next feature to be described. To the north side there is a void in the base of a shaft of uncertain diameter, backfilled above and to one side. This is probably Old Smithy Shaft (see above). The adjacent passage was clearly considered unstable while in use and as a result there are several notches and iron spikes that held timbers to support the roof. Sometime after 1774, perhaps in the late 18th or early 19th centuries, this area was walled-out with drystone walls to the roof placed at both

ends to seal it, presumably because of its unstable nature; a short bypass passage was created to the south side, perhaps shortly afterwards. While this is not identified in the detailed accounts, these are missing for much of 1775-76, 1779, and from the early 19th century onwards. The only contrary dating evidence found was a large shothole of later 19th century type, with a diameter of 34mm, in a piece of rubble on the floor of the chamber; however, this stands in contrast with shotholes of 24-25mm diameter in the undated bypass passage. The finely-made arched section of the sough to the 1774 tail has also been modified after further collapse in the 1880s, and the outer third has been rebuilt in a slightly different style.

The main accessible part of the old sough is entered via a short cross-cut from the 1769 New Smithy Shaft. The first section of the old sough has been largely backfilled and this rubble is retained by a high drystone wall at the side of the 1774 sough passage, with another opposite blocking access to New Smithy Shaft. Several shotholes, all with diameters over 30mm, in the stones used, suggest this blocking was done in the 19th century; New Smithy Shaft presumably became redundant (except perhaps as a ladderway) when Salts Level was driven in the first decade of the century. Beyond the low crawl over the blocking in the old sough, in a stretch of sough that appears to have been widened to 1.7m and that has notches and an iron spike for three roof supports, an intact section of original sough remains which is partly filled with water. This passage is mostly 1.1 to 1.3m wide and is now 1.9 to 2.3m high, with a clayey silt in the bottom and a dangerously unstable roof. One shothole was found with a diameter of 24mm. To the south side there is a walled-up and backfilled side level of unknown purpose. Perhaps mineral was found here, or it may be there was a now lost ladderway to the dressing floors above. At the end of the main sough passage, immediately before a total collapse, the sides are drystone walled, carefully built and set 0.7m apart; it may be that the sough from here to the tail

had a flat rather than arched roof. This is consistent with Efford's 1769 published account of walling given above. His stated height of 4.5 feet (1.4m) may be a little low, either due to underestimation or more probably because of the presence a wooden walkway in the sough, placed above the running water, as noted by Harper at around the same date. This passage was inconveniently narrow for haulage and this is another indicator that ore was not transported this way but was hauled up the Smithy Shafts.

The Dressing Floors

While much of what is visible today at the dressing floor south of Salts Level dates to enlargement and refurbishing from the early 19th century onwards, a hollow is visible at what is probably the 1769 New Smithy Shaft, which is known to have still been open in the early 20th century. This was certainly used for hauling to the dressing floor, as indicated by extensive rope wear on the inner face of the arching at the base of the shaft. There is no surface indication of the earlier shaft nearby; this may well have been filled in the late 18th century, probably when a leat to the dressing floors from the east side of the hill was made in the 1780s. Undoubtedly the 18th century dressing floors were somewhat smaller than what followed, the later floors expanding as more material was tipped downslope with the driving of Salts Level and at other times over the decades. In the robbed west face of the hillock parts of a stone wall with two rotting horizontal timbers above have been exposed a short depth below the present floor level, which certainly pre-dates the last remodelling and may be relatively early in date.

What prompted the dressing floors to be sited on the hillside in the first place rather than at the valley bottom is not clear. One possibility is that they were placed to serve both Deep Ecton and Dutchman Mines, the site being a suitable compromise part-way between the two. The choice of an unsuitable steeply-sloping site may well have been overcome by making an initial platform with the rock from driving Deep Ecton Level, which was drawn up Old Smithy Shaft. It is tempting to postulate that their position was also influenced by the presence of the water that issues from Dutchman Level, which could potentially have provided a source of necessary water for dressing. However, it must be stressed that there are no obvious indicators of leats or launders between here and the dressing floors, although these could easily have been set above ground. The main water supply in use later, the long leat noted above, was not created until 1783-87; without an alternate supply of water it is hard to envisage any form of dressing floor here being viable and yet there is strong evidence to suggest they have been here since at least 1760. The one advantage a dressing floor here had over one at river level is that, if water was available from above, then gravity could be used effectively for transporting ore through all stages in the process. However, even then, the floors did not have to be anything like the 30m above the river of the site chosen.

Dutchman Mine

The workings here, including the Dutchman Level and the workings following thin mineralised deposits between steeply inclined beds rising to surface, have been described previously in detail (Barnatt *et al.* 1997; Barnatt and Thomas 1998). Dutchman Level has been demonstrated by the estate accounts to pre-date 1760. While some of the workings above are prehistoric and 17th century in date, Dutchman Level was almost certainly driven sometime between 1723 and 1760, perhaps during the period of the second lease from 1739. Similarly, some of the shafts on the hilltop above probably date to this period, while others could be

earlier. It is known that later working took place at the mine from the 1790s onwards. However, all but one of the five currently known shafts are shown on a pre-1809 map. The exception (E10 following Barnatt *et al.* 1997) was sunk or reinstated in about 1816-18. It may well be that the others pre-date the 1790s (and thus 1760), for the accounts refer to the 'opening of an old shaft at the top of the hill' in 1796, but no new sinking is recorded in this period. In the same six weeks in 1796 Dutchman Level was extended by nine feet (3m), with a further driving of forty-nine and a half feet (15m) later in the year; this may well suggest it was the shaft (E12) that intersects the level that was reinstated.

The date of the three known shafts at the adjacent Master's Pasture Mine to the east, and whether they were seen as part of Dutchman Mine, remains obscure.

CONCLUSIONS

It is hoped that this paper helps demonstrate the value of combining historical research with archaeological observation and recording of mining remains. This combination clarifies the detailed development of the mine in the period between 1723 and 1760. Taken together, the two approaches indicate that:

- * The sough was driven from the west side of the hill at this time, but has subsequently been widened over much of its length and the outer part was redriven in 1774 on a divergent line, presumably after a collapse.
- * Ore and waste stone were not taken out of the sough tail, but were drawn up Old Smithy Shaft near the inner end of the original sough's narrow walled section through unstable ground.
- * The dressing floors were sited on the steep hillside at the top of Old Smithy Shaft, in the same location as those used in the 19th century after the completion of Salts Level.
- * The main pipe working was not intersected by the sough until after 1739, by which date workings here were had already been sunk deeper. The sough may well have been completed in 1740 when ore production increased, or possibly in the early 1750s when it increased again.
- * Large and exceptionally rich pipeworkings had been reached at depth, something like 60m below sough level, before 1759. This probably took place in the early 1750s or shortly afterwards.
- * Dutchman Level was driven prior to 1760, perhaps in the period after 1739.
- * All of this work was carried out using powder, but the mine was largely unmechanised, the known exception being a gin engine used at the hilltop shaft. Only churn pumps and hand-wound water barrels were used underground.

While some of these conclusions have been arrived at during a previous study (Robey and Porter 1972), that the sough ran from the west of the hill has only more recently been realised, while the placing of the dressing floors at the same site as those used in the 19th century, with ore drawn up shafts, is a radically new interpretation.

Questions that have not yet been fully resolved are:

- * What depth had mining in the main pipe reached prior to 1723?
- * What is the date of the hilltop shaft documented by Roose in 1759?

* Were the shaft at Apes Tor and the boat level at 34 fathoms below the sough started before late 1760?

The answers to the first two inter-related issues are uncertain. Plot writing in 1679, and describing the 1660s mining, states that the workings at Ecton were up to 50 yards (45m deep); these may well have been in the main pipe (Barnatt *et al.* 1997). Thus, if Plot was correct, it is unlikely that river level had been reached at this date. However, it is unclear if the Hooson account should be interpreted as indicating an otherwise undocumented mining episode in the late 17th or early 18th century; if this took place, then the pipeworkings could have been significantly deepened at this time. Translating Roose's overstated depths for mining between 1723 and 1759 as correct proportionally, this suggests that ore was not obtained until a little over half way down from surface to the sough level, thus the main pipe may possibly have been worked out to a depth of about 55m prior to 1723 (and more if the 1723-59 ore was primarily obtained from side branches to the pipe). Whenever the workings in the pipe below river level were started, that there are two trial levels from the pipe situated just above sough level may well suggest ore-rich deposits in this area were worked out before the sough intersected the pipe in 1740 (or somewhat later). These trials were driven with powder before the main working level determined by the sough was established and they are likely to post-date the working of the rich deposits here, driven in an attempt to find further ore-bearing mineralisation. Given the small size of the shotholes they are likely to either relate to the postulated Hooson episode of mining, or to post-date 1723. One potentially crucial piece of evidence in determining when the pipe was mined near river level is the misalignment of the sough and the sinuous nature of its inner end, for if the twisting pipe had not reached this depth in 1723, then the exact orientation in which to start driving would have been difficult to calculate. However, this misalignment can be alternatively interpreted as simple mis-survey and thus the pipeworkings could have been deep. One possible argument in favour of this suggestion is that most evidence for small early shotholes in the pipe above river level has been found in side workings, suggesting the possibility that the richer deposits in the main pipe were worked earlier. In summary, this issue remains unresolved.

The date of the hilltop shaft is uncertain as it breaches pipeworkings at 42m below surface and this is within the working depth thought to have been reached in the 1660s. Alternatively it could have been sunk later to facilitate extraction from somewhat lower in the pipe. It was certainly in use in the 1723-60 period of working, but whether this relatively large diameter shaft was sunk then or perhaps only widened is still unclear.

The date of the ambitious Apes Tor entrance to the mine with its gin engine shaft and boat level at 34 fathom depth is still uncertain, it was either a project conceived and executed between 1762 and 1765, or this known phase of development completed or extended a pre-existing arrangement created in the 1759-60. The resolution of this issue is hindered by the inaccessibility of most of these flooded workings. It is hoped that further analysis of the six-weekly accounts and other historical documentation, which is ongoing as part of assessment of the post-1760 workings, will cast further light on the problem.

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REFERENCES

- Althin, T. 1971 Eric Geisler and his journey abroad of 1772-3. *Med Hammare och Fackla* 26, 52-127.
- Barnatt, J. 1999 Prehistoric and Roman mining in the Peak District: Present knowledge and future research. *Mining History* 14.2, 19-30.
- Barnatt, J., Rieuwerts, J. and Thomas, G. H. 1997 Early use of gunpowder in the Peak District: Stone Quarry Mine and Dutchman's Level, Ecton. *Mining History* 13.4, 24-43.
- Barnatt, J. and Thomas, G. H. 1998 Prehistoric mining at Ecton, Staffordshire: A dated antler tool and its context. *Mining History* 13.5, 51-64.
- Efford, W. 1769 A description of the famous copper-mine, belonging to his Grace the Duke of Devonshire, at Ecton-Hill, in the County of Stafford. *The Gentleman's Magazine*, February 1769.
- Hooson, W. 1747 *The Miners Dictionary*. Wrexham.
- Pickin, J. 1999 Stone hammers from the Ecton Mines in the Bateman Collection, Sheffield. *Mining History* 14.2, 15-18.
- Plot, R. 1686 *Natural History of Staffordshire*.
- Porter, L. and Robey, J. 2000 *The Copper and Lead Mines around the Manifold Valley, North Staffordshire*. Ashbourne: Landmark.
- Roberts, P. K. 1981a Boat levels associated with mining: I. Coal mining. *Industrial Archaeology Review* V.2, 85-95.
- Roberts, P. K. 1981b Boat levels associated with mining: II. Metal mining. *Industrial Archaeology Review* V.3, 203-216.
- Robey, J. and Porter, L. 1972 *The Copper and Lead Mines of Ecton Hill, Staffordshire*. Ashbourne: Moorland.
- Timberlake, S. 2001 Mining and prospection for metals in Early Bronze Age Britain - making claims within the archaeological landscape. In: Joanna Bruck (ed.) *Bronze Age Landscapes: Tradition and Transformation*. Oxford: Oxbow Books

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