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CROMFORD SOUGH AND THE EARLY USE OF GUNPOWDER

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Abstract

A study of the early part of Cromford Sough, currently accessible for nearly 2000 feet, together with the branch level along the range of Greatorex and Bedehouse veins, has provided new evidence on the use of gunpowder blasting in the 1670s. The slow adoption of the new method of excavation seems to have been due to a combination of doubtful cost benefits and the danger to the miners.

The technology of 17th century sough construction and hard rock excavation has been discussed elsewhere by the author (1981). Comparisons in mining methods were established between the Derbyshire orefield, other parts of Britain and certain European metalliferous mining regions. The study by Willies (1979) was enlarged upon and an overall hypothesis for chronological development presented. Recent exploration in Cromford Sough by Jon Scaife, Ray Marsh and the author has allowed some re-appraisal of these concepts, yet permitting the major principles advanced to remain unaltered.

The earliest portion of Cromford Sough, originally known as Longe Sough or Ffernes Sough, has its tail southeast of Cromford market place (SK 295568) and was driven south to the eastern limit of Dun Rake during the period 1673/4 to 1680. A branch level trending southwest towards the range of Greatorex and Bedehouse Veins was probably constructed about 1676. These two veins are close together and are ENE splits off Dun Rake near the northern limit of the present Dene Quarry. The Greatorex-Bedehouse branch contains abundant evidence, in the form of shot holes, of excavation by gunpowder. Some of these shot holes contain traces of stone-dust stemming.

The present study seeks to establish that this gunpowder work dates from about 1676 and is thus the earliest such work presently visible in a British mine. The type of stemming pre-dates its claimed introduction into European mining practice by a decade, and by about half a century its introduction into Derbyshire mining as stated by Hooson (1747).

Earlier gunpowder work in Dutchmans Level at the Ecton copper mines, reputedly the site of the first blasting in British mining in 1670, and similar work at Bailey (Bailliffe) Croft Sough, Wirksworth, dating from 1672, cannot be examined, neither being presently accessible.

GEOLOGICAL RELATIONSHIP

The Cawdor Limestones form the western side of Cromford Hill and dip at a shallow angle northeastwards beneath the Cawdor and Edale Shales*. The Cromford-Wirksworth road is along the approximate outcrop of the boundary between the two formations. Exploration has confirmed that the main level of Cromford Sough is driven in the Cawdor Shales immediately beneath the base of the Namurian Edale shales (Rieuwerts, 1981). The Greatorex Vein branch passes through the shales into the underlying Cawdor Limestones. The facies variations within the Cawdor Group have been discussed by Smith et al (1967): the relevant portions of the succession are as follows:

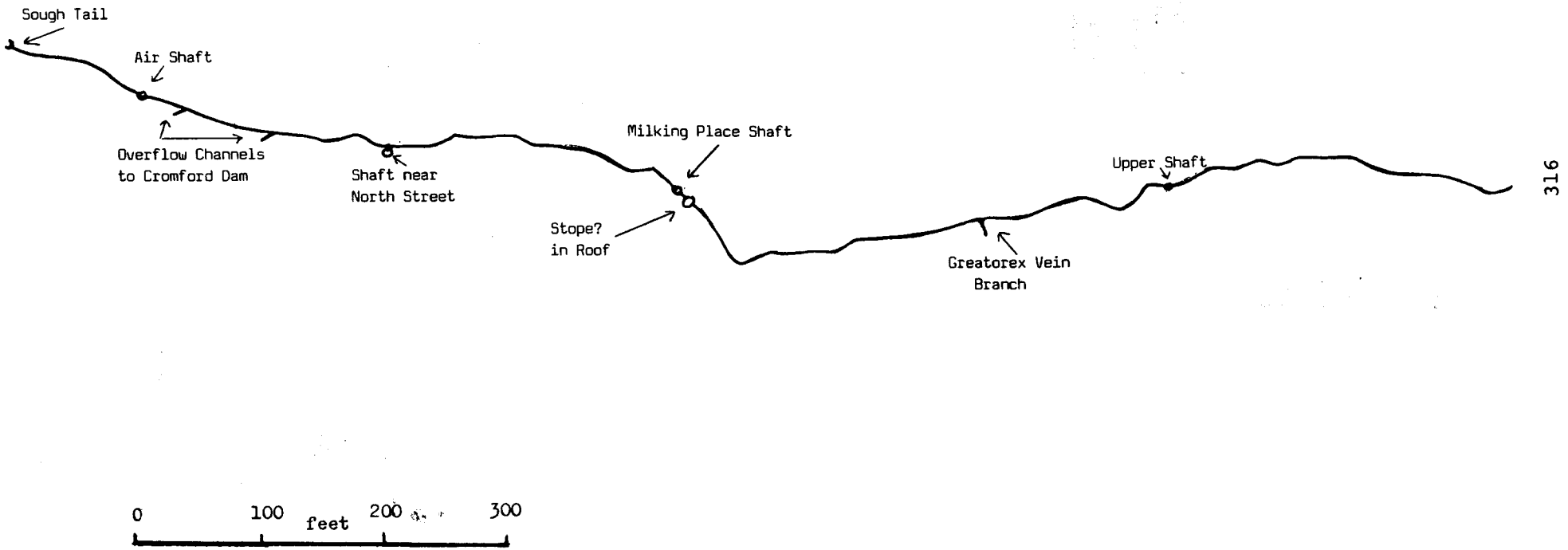
3 Shale with some dark limestone beds
2 Medium-grained grey and dark grey cherty limestone with large Productids
1 Grey and dark grey bedded crinoidal limestone

(after Smith, 1967 Fig.4, p.14)

Mining plans, including the accurate diallings carried out by William Hodson in 1923 (DRO, Rieuwerts L373, L389) show the sough taking a sinuous course (Fig.1) between the tail and the branch level to Dun Rake, and the logical assumption derived from these plans was that the level had been constructed along the irregular shale/limestone interface. Information from W. Hodson, obtained at the time of the 1923 clearing and survey of the sough, was contradictory, and somewhat baffling, he being quite adamant that the sough was driven in solid limestone from the tail to beyond Tinley Vein. Detailed inspection during the

* These two groups of shales would have been regarded as one and the same in mining days, the present distinction being on fossil content showing that they are of Lower and Upper Carboniferous age respectively; they are therefore shown by different colours on Geological Survey maps.

Fig. 1. PLAN OF PART OF CROMFORD SOUGH FROM DIALLINGS CARRIED OUT IN 1923 BY WILLIAM AND THOMAS HODSON



recent explorations has proved Hodson's information to be inaccurate though slightly different from that postulated previously by the author (1981).

The main sough is driven approximately along the strike in the highest beds of the Cawdor Group, principally in hard shale with a prominent limestone band about 20 inches in thickness variously occupying the floor, mid-height or roof of the passage because of minor folds and flexures in the strata. The limestone is hard but well-jointed and, somewhat surprisingly, the soughers made no effort to avoid it. Low-angled shear planes were occasionally observed in the shale. The apparent dip is about 10° towards the northeast, locally steepening as the sough passes through minor flexures.

A conspicuous southwest-trending branch level has been cut against the dip along the inferred range of Greatorex and Bedehouse Veins, both off-shoots from Dun Rake. Driven initially in hard shale, it passes after 135 feet into the underlying Cawdor Limestones, here composed of dark grey medium-bedded limestone with abundant *Gigantoproductus*. Thin, dark grey limestone bands within the shale become more prominant as the Cawdor Limestones are approached.

Beyond the contact with the limestones, part of the branch level is cut along a very thin scrin or mineralised leading containing barite and some disseminated galena. A cross-scrin approximately 530 feet from the main sough carries an identical mineral content, together with small isolated patches of a bright green mineral, possibly rosasite or aurichalcite. A little blue-green flowstone can be observed in the roof of the leading. Locally, Dun Rake is often claimed to have been a copper mine though no documentary evidence substantiates such a claim. Sporadic copper mineralisation has been found in Dene Quarry adjacent to Dun Rake.

At the cross-scrin the branch level passes into the underlying grey crinoidal limestones and continues in these to the end at about 700 feet from the main Cromford Sough.

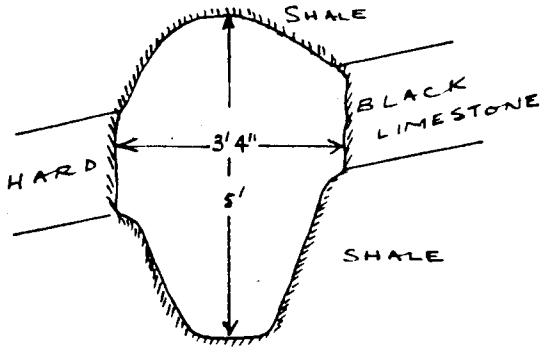
RECENT EXPLORATION

Cromford Sough is entered from the bottom of a sunken, walled enclosure situated behind the houses on the southeast side of Cromford market place (SK 295568). Two arched tunnels in the base of the opposite wall convey the sough water away toward the River Derwent. The first few yards of the sough are walled and arched with dressed gritstone. 150 feet in from the present tail a low arched level doubles back towards Cromford at an acute angle. Water was once diverted along this to the mill dam, but it is now heavily silted. A second brick-arched level also doubles back a few yards further in and it too is thought to have led water to the dam but a trickle of water from an unknown source now flows out over the silt. These two branches were not part of the original sough but were part of an elaborate late 18th century arrangement to maintain a water supply to Sir Richard Arkwright's cotton mill. The system was augmented by Cromford Mill Dam, fed by Bonsal Brook.

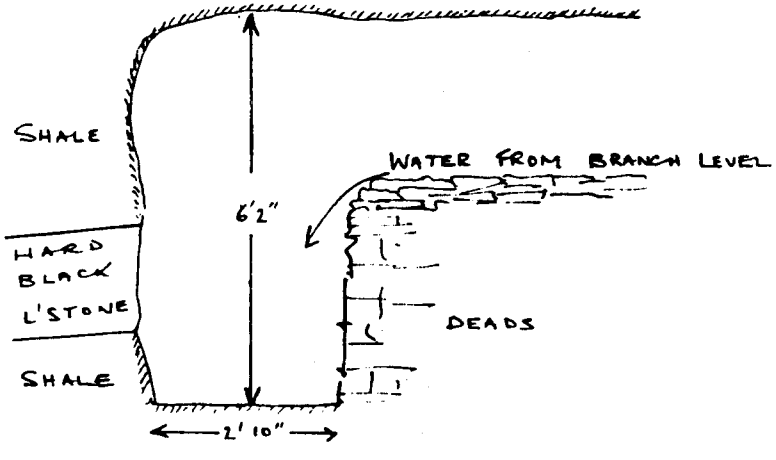
The sough originally continued northwards across the site of the walled enclosure to a tail on the roadside opposite the present Greyhound Hotel car park, but this section of the sough has been totally destroyed during the construction of the Mill water-supply system and the adjacent buildings. The first air shaft on the sough was also destroyed.

Beyond the arched section the sough soon passes into hard shale and thereafter is unlined. Three shallow air shafts, one covered at roof height by large gritstone slabs, occur within 320 feet of the tail. A little over 550 feet from the entrance, Milking Place shaft is reached, sunk directly onto the sough at SK 295566. Some stemples remain in the shaft; others that have fallen to the shaft foot are coated in flowstone. One plan (SCL, Bag 180) shows a vein called Rainbow Vein ranging approximately E-W at this shaft; exploration of a cavity in the roof a little beyond failed to establish whether it was a stope developed in shale on the range of Rainbow Vein or a parallel shaft. Lack of any sign of mineralisation in the shale suggests that at best it was a futile exploratory project. The sough is variable in height and cross-sectional shape. The height varies from 5 to 6 feet and the width from 2 ft 10 ins to 3 ft 4 ins. Where the roof is cut is shale it often shows pick-marks; the wider part of the cross-section is where the hard limestone bed has been wedged out in blocks once the shale had been removed. Due to minor folds and flexures in the strata the limestone may appear at floor, mid-height or roof level, but by twisting the course of the sough the miners seem to have tried to keep the limestone at a convenient mid-height.

Fig.2. CROMFORD SOUGH

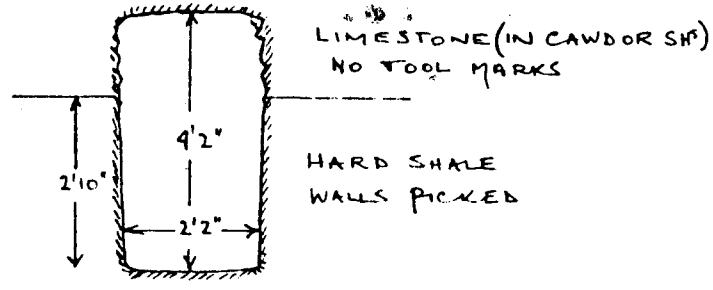


(a) Section of the main sough near the Greatorex branch level.

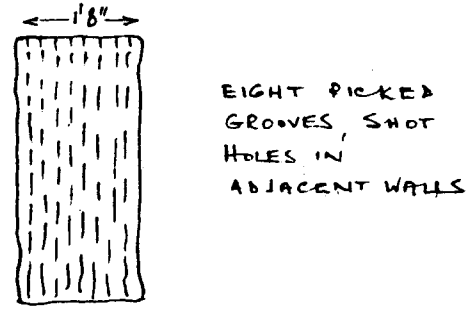


(b) Intersection of the main sough and the Greatorex-Bedehouse branch.

Fig.3. GREATOREX-BEDEHOUSE BRANCH LEVEL



(a) Cross-section near limestone/shale contact.



(b) Forefield in solid limestone.

THE GREATOREX-BEDEHOUSE BRANCH LEVEL

At a distance of 858 feet from the sough tail a conspicuous branch level leaves the main sough on its west side. Up to this point only three shot holes have been observed. Their significance, together with those more prevalent in the main sough beyond the branch passage, will be discussed in due course.

Somewhat curiously the branch level joins the main sough about 3 feet 6 inches above the sole of the latter, and a stream of water issues from it. A possible explanation is that when Cromford Sough was extended during the years 1706 to 1709 the cross sectional area of that part of the sough already in existence was too small to accommodate the anticipated increased water flow. The agreement for extending the sough beyond Tinley Vein, where it had been abandoned in 1696, states that the sough-masters

> "shall open, drive, perfect and carry on a sough, addit or watergate, to begin at the mouth or tayle of the Longe Sough in Cromford towne" (Wolley 6684 f145-152)

The context implies that the existing level was to be cleaned and enlarged. It could be suggested therefore that the branch level, by then obsolete, is an unmodified remnant of the original pre-1706 (1696) sough level.

The branch passage takes a sinuous course (Fig. 4) and a short, blind heading in shale a few yards downstream in the main sough, together with similar short blind headings in the branch level, suggest a combination of inaccurate dialling and initial failure to locate the northeastern range of Greatorex-Bedehouse Vein in the underlying limestone.

The sough hereabouts has been picked and trimmed (Fig. 3) but nowhere does it assume a 'coffin-level' type passage, neither does the trimming show the characteristic sweeping pick marks on the walls. Eventually, after passing through 135 feet of shale and thin, interbedded dark limestones, the level enters the underlying more massive Cawdor Limestones.

On reaching the Cawdor Limestones the walls of the branch level become liberally marked with shot holes, usually about 7/8th inch to 1 inch in diameter and about 12 inches in length. Gunpowder blackening can be observed adjacent to many holes together with the distinctive longitudinal tension crack. Most of them contain dust and clay but some contain quite distinct remains of clay and rock-dust stemming. In places a thin scrin/leading has been picked out in the roof and one forefield has a narrow groove picked in the mineral vein in the face. Another forefield is 20 inches in width with 8 vertical pick grooves cut down the solid rock face (Fig. 3). No pickwork trimming has been attempted in this part of the passage, the walls being left rough, though the cross-sectional shape is quite regular. The work is therefore reminiscent of, but not identical to, the type of excavation carried out during the mid 18th century period of transition to almost exclusive use of gunpowder (Rieuwerts, 1981).

The branch is of small dimensions throughout, being a little over 4 feet in height and approximately 2 feet in width in both shale and limestone. The significance of these dimensions will also be discussed later.

Some 180 feet from the junction with the main sough a thin mineralised leader was found by the soughers and was followed for 210 feet. A short 'dog-leg' in solid limestone enabled a parallel leader to be followed but no stoping was attempted on either. A shaft was sunk from the surface to the branch level along the second leader, but it has not yet been climbed. The shaft is marked on the Barmaster's 25 inches to 1 mile map situated at the northeastern extremity of Bedehouse Vein (Chats. Bar Coll), but it is not named. A little further along a thin scrin crosses at right angles. Some stoping was attempted but the low galena content was not conducive to sustained search. Both sub-branches on the scrin soon terminate, but the main branch continues as a flat-out crawl due to silt from an open joint, the source of the water flowing in the level. Beyond, the passage soon closes at a forefield in solid rock with no sign of mineralisation.

CROMFORD SOUGH BEYOND THE GREATOREX BRANCH

The main drive of Cromford Sough continues beyond the Greatorex Vein branch for a further 1142 feet to where a large fall of shale prevents further progress at 1900 feet. At the time of Hodson's survey in 1923 he was able to get a further 1500 feet or so further up the sough, beyond the

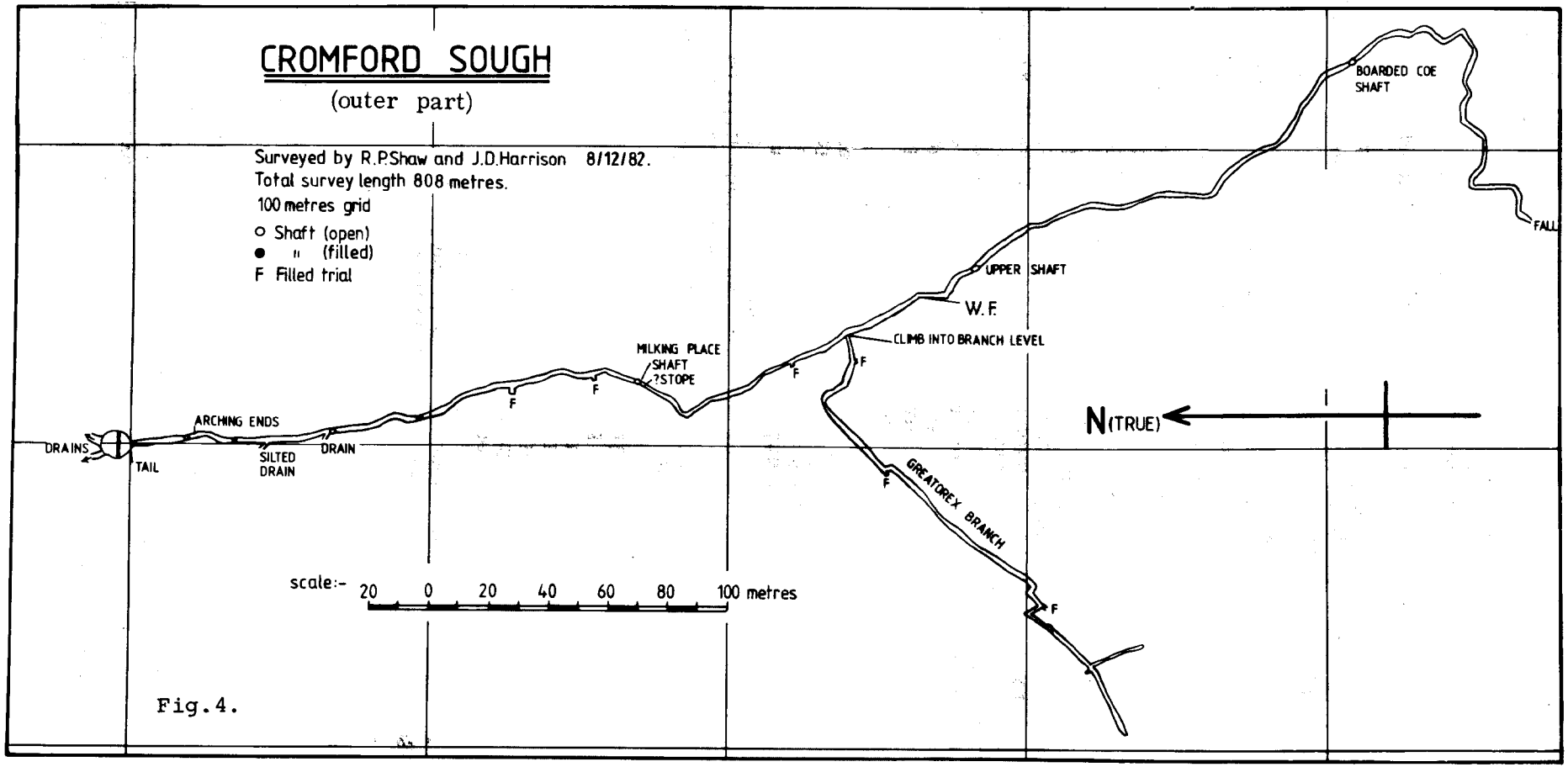

CROMFORD SOUGH
(outer part)
Surveyed by R.P.Shaw and J.D.Harrison 8/12/82.
Total survey length 808 metres.
100 metres grid
o Shaft (open)
● " (filled)
F Filled trial
BOARDED COE SHAFT
FALL
UPPER SHAFT
W.F.
CLIMB INTO BRANCH LEVEL
MILKING PLACE SHAFT ?STOPE
ARCHING ENDS
DRAINS
TAIL
SILTED DRAIN
DRAIN
GREATOREX BRANCH
N(TRUE)
scale:- 20 0 20 40 60 80 100 metres

Fig.4.

Rogden Coe branch level. Two shafts descend on to the sough, the Upper Shaft, 170 feet past the branch passage, is of large dimensions and was probably a winding shaft (SK 295565). It intersects the sough so accurately that either the dialling was of exceptional quality, or more likely the shaft was risen rather than sunk. The last shaft presently accessible is Boarded Coe Shaft (SK 296564), the names being based on a plan of Cromford Sough made in 1777 (SCL, Bag 180).

The sough between the Greatorex-Bedehouse branch and the terminal fall was excavated in the upper shaley beds of the Cawdor Group. About 70 feet beyond the Greatorex-Bedehouse branch the initials W.F. are cut into the wall: no name can be attributed to them at present.

The three isolated shot holes visible in the main sough may be either trial firings similar to those thought to have been made in Bailey Croft Sough in 1672 (Flindall, 1975; Rieuwerts, 1981) and would pre-date those in the branch level, or alternatively they may date from the period of suspected enlargement of the original sough sometime between 1706 and 1709.

Shot holes can be observed more frequently beyond the branch level, but they are not common, have no regular pattern and were used only to break away more obstinate pieces of limestone, the roof being picked in shale. They may also date from either period.

RE-APPRAISAL OF GUNPOWDER BLASTING METHODS

If the concentrated gunpowder work visible in the Greatorex-Bedehouse branch sough does date from the 1670s, the techniques and skill acquired during its construction did not result in expansion of the new technology elsewhere in the orefield.

Construction of hand picked levels excavated in solid limestone and, occasionally, other rocks continued in the Derbyshire lead mining field until at least the 1760s, approximately 90 years after the initial employment of gunpowder in British mining. The very slow adoption of blasting with powder and the long-continued usage of hand methods, for sometimes the two processes were in use concurrently in the same mine, present a complex problem requiring further research. The author has previously suggested that two inhibiting factors, though there may have been others, were the relatively high cost of gunpowder and the danger in its application. The former concept now requires some modification in the light of calculations carried out herein. These demonstrate that it was the high bargain payments demanded by the miners when using powder, rather than the price of gunpowder itself.

There is limited evidence from reckoning books and other documentary sources to indicate that gunpowder may have been used only spasmodically, though locally intensively, through the orefield until well into the 18th century. Concentrated use of powder was employed at the Dovegang Mines between 1676 and 1682, at Cromford Sough in the 1680s and at Ratchwood Mine and Oden Mine in the late 17th and early 18th centuries. In contrast small quantities were recorded at many of Richard Bagshawe's mines in the Casteton and Bradwell area during the early years of the 18th century (SCL, OD 1149).

The absence of payments for gunpowder in mine reckoning books is not necessarily indicative of non-usage as the bargain payment system often stipulated that the miners were to provide their own candles and powder.

The present research, though admittedly derived from few documentary sources, indicates that during the last quarter of the 17th century, miners were able to demand substantially higher pay when using gunpowder, very probably as a direct consequence of the dangers involved (Table 1).

TABLE 1 Comparative costs and progress achieved at Bates Sough (Dovegang Mines), using gunpowder in hard ground, and at Bailey Croft Sough using hand methods in similar conditions.

Bates Sough (gunpowder blasted) (see Table 2 for suggested work rota).

(i) Rate of advance 3 inches per day (1 ft 6 inches per week)
(ii) Bargain Rate, usually £8 per fathom (4 weeks work)
Gunpowder - approx. 2 oz to 3 oz. per hole @ 10d - 1/- per lb.
approx. 36 shot holes per fathom (9 per week)
Therefore cost of powder per week would be between:
9 holes with 3 ozs powder @ 1/- per lb = 1/8d (maximum)
or 9 holes with 2 ozs powder @ 10d per lb = 11d (minimum)

/contd.

Table 1 contd.

Remuneration, per week = £8 ÷ 4weeks =	£2	0	0	
		1	8	maximum powder cost
	£1	18	4	

Probably only 4 men employed - see Table 2
Therefore each man received about 1/7d per day shift.

Bailey Croft Sough (cut by hand) (from Rieuwerts 1981).

Bargains. £6 per fathom. 2 shifts @ 1½ inches per shift
= (1 foot 6 inches per week).
= £1 10 0 to divide between 4 men for one week
Therefore each man received 1/3d per day shift

The higher rate of remuneration received by the miners at Bates Sough continued even when the sough encountered much softer ground. Bargain rates dropped dramatically, but naturally the rate of progress increased. Very probably the miners were provided with gunpowder in addition to their bargain payments, particularly for the last two accounts when it was noted they received their money "besides materials".

May 19th 1678 to 5th October 1678 (= approx. 120 working days in Bates Sough)

Distance driven	Total cost	Cost per fathom
15 fathoms	£36 9 5	from £2 1 8 to £6 0 0 usually about £2 10 0 per fathom.

90 feet in 120 days = 9 inches per day
£36 9 5 (8753d) ÷ 120 days = 73d per day, for 4 men
is about 1/6d per shift each man

TABLE 2 Suggested work rota and weekly rate of advance for late 17th century cross-cut level excavated through hard stone or in a tight vein or scrin, using gunpowder.

		Four miners employed.
DAY 1		
Shift 1	Pick groove in forefield about 1 foot deep	2 men
Shift 2	- " -	2 men
DAY 2		
Shift 1	finish picking 'v' notch groove	2 men
Shift 2	Clear face - about 400 - 450 lbs of stone	2 men
DAY 3		
Shift 1	Bore 6 shot holes in face	2 men
Shift 2	Prime holes and fire	2 men
DAY 4		
Shift 1	Clear face - about 800 - 850 lbs	2 men
Shift 2	Finish Clearing face	2 men

Overall rate of advance 1 foot 6 inches per week.

TABLE 3 Suggested work rota and weekly rate of advance for late 17th century cross-cut level, excavated through soft ground, e.g. vein or wide scrin, using gunpowder.

		Four miners employed
DAY 1		
Shift 1	Cut out centre of vein, say just over 1 foot deep, begin boring 6 shot holes	2 men
Shift 2	Complete boring 6 shot holes, prime and fire	2 men
DAY 2		
Shift 1	Clear and transport rock to shaft	2 men
Shift 2	As shift 1 - Day 1	2 men
DAY 3		
Shift 1	As shift 2 - Day 1	2 men
Shift 2	As shift 1 - Day 2	2 men
DAYS 4 - 6		
	Repeat as above.	

From Dovegang Mines reckoning book, Bates Sough advanced 9 inches per day, using gunpowder. Therefore the three days (six shifts) outlined above would make about 2 feet 3 inches of progress.

Gunpowder varied in price from 10d per lb. in 1676 at Dovegang Mine to 1/3d per lb. at Oden Mine in 1706. Though the price of one pound was therefore equivalent to the contemporary daily wage, the cost of powder used in excavation was relatively low in comparison with the equivalent remuneration derived from bargains (Table 1).

Some sources, e.g. Hooson (1747) and White Watson (1811) claimed that initially iron plugs and wedges of varying design (Fig. 5) were used to secure the gunpowder charge in the shot holes, stemming with stone-dust, clay and similar materials being introduced at a later date. The iron plug (gun) and wedge (quinnet) as described by White Watson, were newly in use in the Mendip lead mines in 1683/4 (Beaumont, 1684), whilst very similar pieces of equipment were in use pre-1715 in the Allenheads Mine (Crawhall, 1820) (Fig. 6). If White Watson is correct the slug and clippet were in use before the gun and quinnet, the latter being introduced to improve safety.

Both Hooson and White Watson stressed the dangers associated with the use of iron plugs and wedges. The Dovegang Mine accounts (RGO 33), record the Barmaster and members of the Barmoot Jury enquiring in November 1678 into "the (they) that was killed" ; these men worked in Bates Sough and may possibly have been killed during blasting operations in the level. A miner was killed by 'plug and wing' in a mine at Eyam in 1699.

Hooson claimed that the safer method of shothole stemming was introduced into British mining by miners from Saxony during the early part of the 18th century, but references to the use of old sheets for stemming at Dovegang Mine in 1676, the reputed shot hole with straw fuse dated 1678 in Golconda Mine, Brassington (Kirkham, 1953), together with the present evidence from the Cromford Sough branch level necessitate some re-appraisal of Hooson's comments and also those general technological histories quoting the invention of clay and stone stemming by a German miner, Karl Zumbe, in 1687 (Daumas, 1964).

It should be pointed out that later entries in the Dovegang Mine accounts state that sheets were to be used for stemming churn pumps, but the references dating from 1676 make no mention of pumps in that context.

Excavation of the Greatorex-Bedehouse branch passage through limestone was accomplished by initially picking out a narrow groove in the mineral content of the scrin or leading, followed by blasting the remaining hard rock with a close pattern of shot holes.

The dimensions of these holes, ⅞-1 inch diameter, are not significantly different from those made throughout the following century, and certainly bear no resemblance to the reputed large holes (3 feet x 2 inches) made at the Ecton Copper mines in the 1670s.

No pickwork trimming was carried out in the small level and this contrasts strongly with later cross cuts which resulted in a larger sized passage.

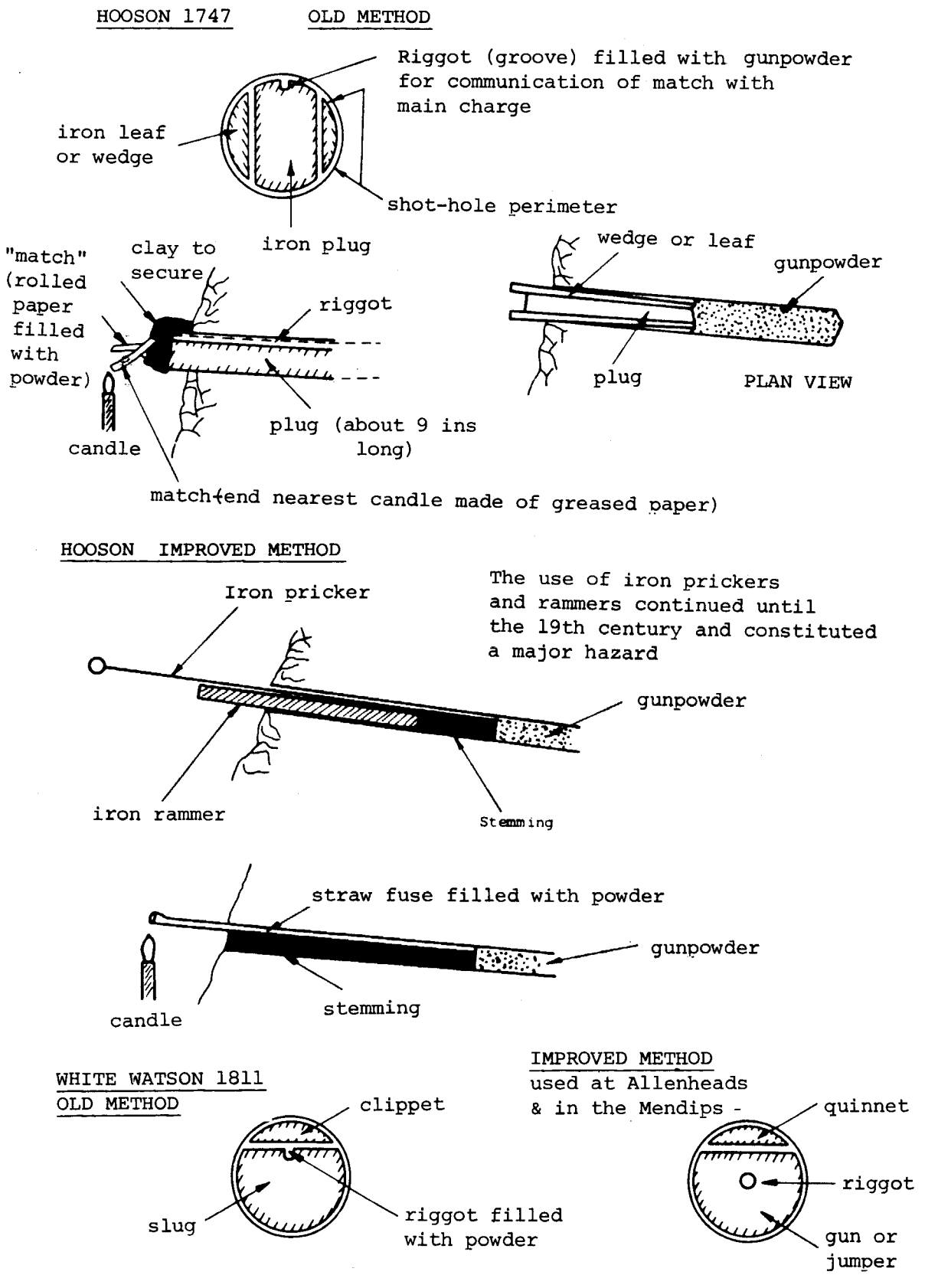
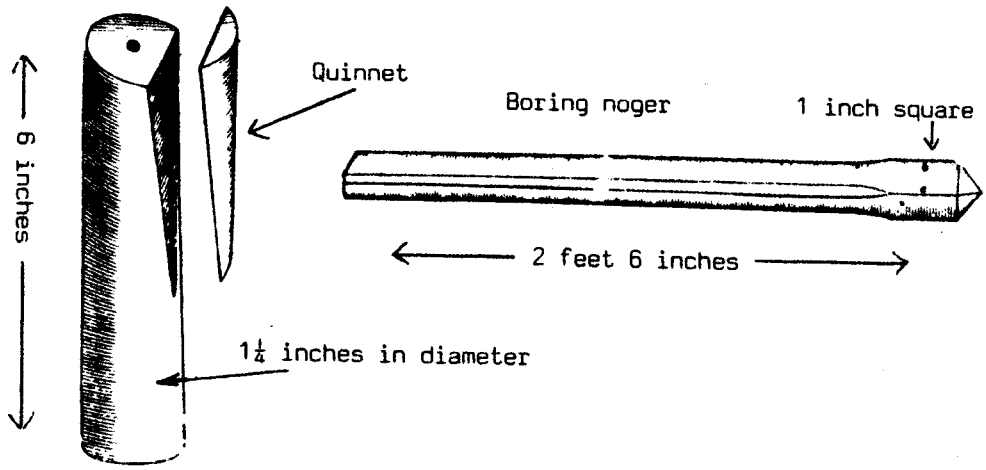


Fig.5. Methods of stemming shot holes.

Fig. 6.

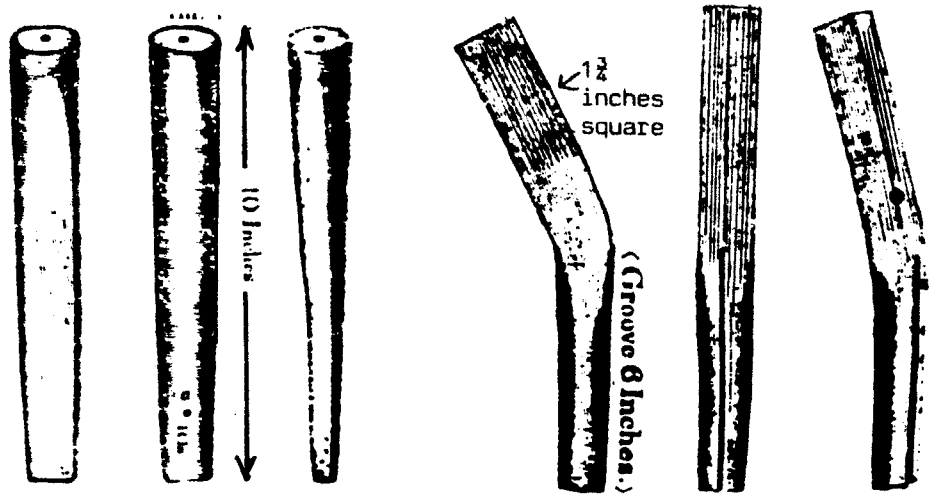
Blasting Implements Used In The Mendip Lead Mines, 1683 (Beaumont 1684-85)



Gun - used for securing gunpowder charge in shot hole

Blasting Implements Found In Allenheads Mine, Northumberland in 1820 (Crawhall, 1820)

Strong timbers fixed across upper part to prevent charge blowing out



Iron plug for securing gunpowder charge in shot hole

1 inch in diameter

Riggot ¼ inch wide

The branch level, however, does have a reasonably well-trimmed cross-sectional shape and this was achieved largely by the close spacing of shot holes.

The stemming material, clay and rock dust, is also important historically, it may have been indigenous to Derbyshire and not to Germany as believed previously.

Sough and mine proprietors rarely stipulated minimum dimensions for a level; furthermore, Tables 1 and 2 demonstrate that weekly progress at Bates Sough, where blasting was used throughout, was no greater than in Bailey Croft Sough driven by hand work alone. The implications are that the cost to the mine or sough owners was substantially higher if a level was blasted, with no immediate improvement in drivage rate. Additionally the miners, though financially better off, were no doubt acutely aware of the dangers involved. Thus, until the new technology had been refined so that longer and more judiciously placed shot holes ensured faster progress and more commodious passages, together with removal of some of the attendant dangers, there was little incentive to either employer or employee to use gunpowder exclusively. The traditional conservatism of most miners and their reluctance to accept change may also be significant. No doubt the construction of 'coffin levels' utilizing a refinement of pickwork alone was consequently encouraged by some mine owners resulting in the creation of, for example, two major early 18th century drainage levels, Wildersley Sough and Winster Sough, and the fine mid 18th century examples to be seen in Ball Eye Sough, Masson Sough (Youds Level) and Whalf Sough.

Hand-picked levels have been recorded in many British metalliferous mining areas, but so far none except those in Derbyshire appear to have been dated accurately from documentary sources.

HISTORY OF CROMFORD SOUGH TO 1696

It is not proposed herein to discuss the history of the sough beyond its intersection with Tinley Vein in about 1696, and the earlier history only in sufficient detail to establish the historical setting relative to the driving of the branch level along the range of Greatorex and Bedehouse Veins.

No original Articles of Agreement have survived; the late Miss N. Kirkham believed that the sough was begun about 1672 but presented no evidence (Kirkham, in litt.). Present research suggests that the start was somewhat later, perhaps 1673 or early 1674.

The first documentary record of the sough dates from January 1676 when Articles of Agreement were signed between the owners of Longe Sough or ffearns Sough and 61 mine owners. The level was already in existence at that date because it was to be extended.

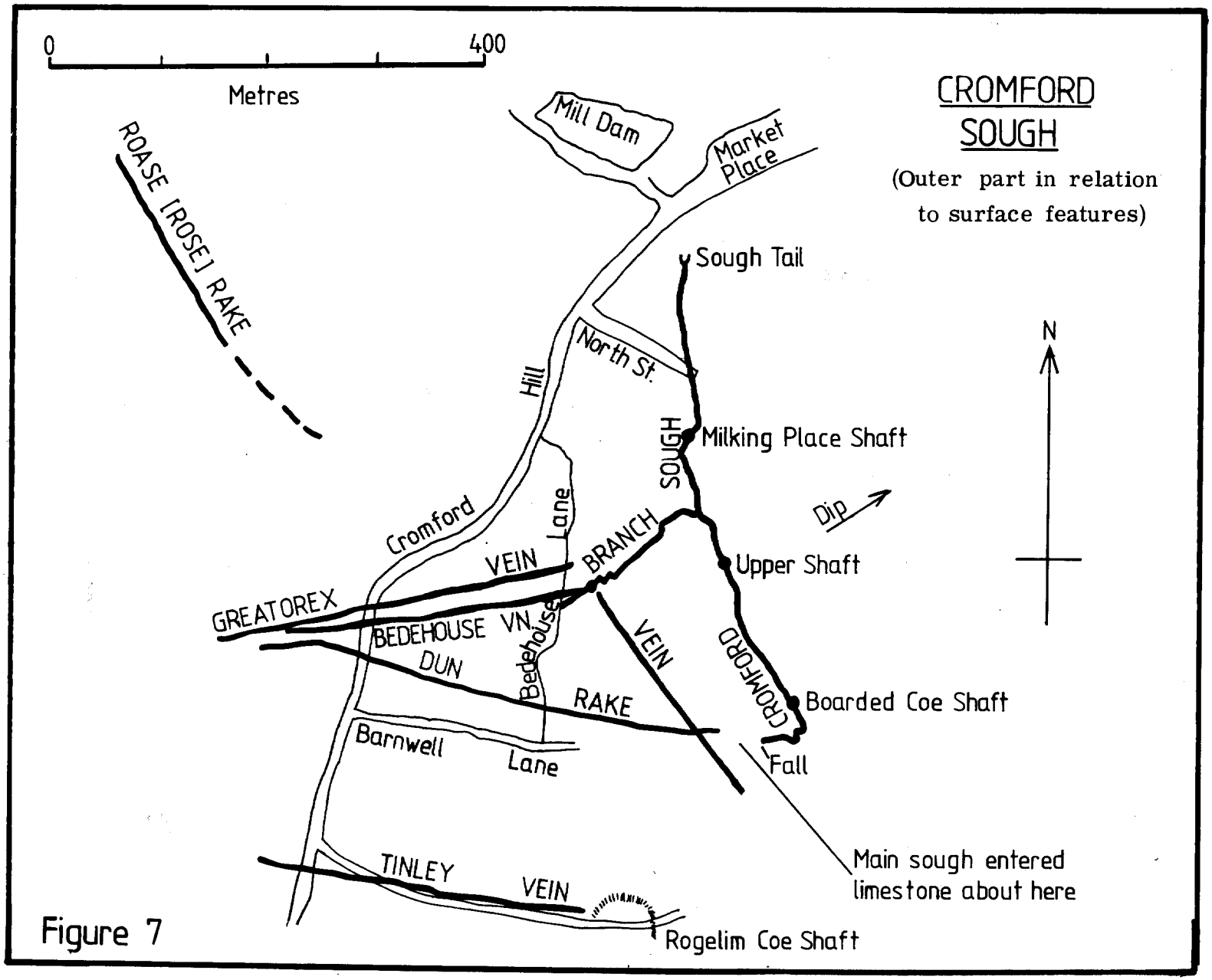
> "from the forefield or upper end thereof ..... and lay dry all the meers in Tinley Vein, Dun Rake, Roase Rake and Ashcross Vein" (DRO, Gell 47/7b)

The range of the sough is interesting (Fig. 7) the intention being to dewater all the above-mentioned veins, (except Roase (Rose) Rake), several meers to the east of their intersections with the earlier and much higher Bates Sough. The soughers could not have known previously the exact course of those veins in the limestone deep beneath the shales and furthermore, although the disposition of the shale/limestone contact was known at Bates Sough contour, its position could not have been accurately forecast at Cromford Sough level. This uncertainty was no doubt responsible for the irregular range of the Greatorex-Bedehouse branch as it twisted in the shale seeking those veins in the underlying limestone and for the blind headings in the west wall of the main sough made to check the position of the limestone. The position of Roase Rake precludes any possibility that the main sough was intended to unwater either that vein directly or the adjacent Horsecroft workings and it appears highly likely that drainage was planned via the Greatorex Vein branch level, though no connection was made between the two.

The Articles then continue:

> "if the mynes belonging to Tinley Veine ..... shall refuse to Drive a Drift at the Level either in regards of the hardness or other wayes then the soughers ..... shall drive them thorrow"

There is a hint in the above statement that the soughers were already experiencing difficulties in hard ground, probably in the Greatorex-Bedehouse Vein branch and the Tinley Vein partners might not have been willing to involve themselves in similar problems.


0
400
Metres
CROMFORD SOUGH
(Outer part in relation to surface features)
Mill Dam
Market Place
Sough Tail
ROASE [ROSE] RAKE
North St.
Hill
SOUGH
Milking Place Shaft
N
Dip
Cromford
Lane
VEIN
BRANCH
Upper Shaft
GREATOREX
BEDEHOUSE VN.
Bedehouse
VEIN
CROMFORD
DUN
RAKE
Boarded Coe Shaft
Barnwell
Lane
Fall
Main sough entered limestone about here
TINLEY
VEIN
Rogelim Coe Shaft
Figure 7

At about this time, i.e. 1676, an undated document stated:

> "the owners of Longe Sough are possessed of divers meers of ground in several veynes (to witt) in the Dun Rake about 20 meers, in the Roase Rake 20 meers, in Tinley Vein 12 meers in horsecroft divers meers and some others in other veynes for unwatering whereof and also of all other the meers of ground in the said veynes the driveinge on the said sough is undertaken"

By December 1676 the adventure was proving very expensive

> "being now very hard though in a veyne"

a 1/24th of the reckoning ending at Christmas amounted to £5-7-6 (Soc of Gen. Heath).

No portion of the main sough is driven in mineralised ground until Godbehere Vein is reached. Furthermore the vein referred to in both the above documents cannot be Dun Rake; the former document clearly differentiates between Dun Rake and the sough veins, whilst the sough could not possibly have reached Dun Rake, well over 2000 feet from the tail, as early as 1676. The only logical conclusion to be derived from the above facts appears to be that the vein referred to must be the thin scrin/leading along which the Greatorex-Bedehouse Vein branch is driven. Though the Articles of Agreement do not mention either Greatorex or Bedehouse Veins by name one possibility already postulated is that the branch was also intended to unwater Rose Rake and Horsecroft Mines. The branch level may have been abandoned c.1681-1682 when the Dun Rake branch became effective. John Greatorex of Callow was a proprietor of Cromford Sough from at least 1676 to 1688.

No plans seen by the author show this branch level. The detailed plan of Cromford Sough drawn by Samuel Hutchinson about 1725-1730, possibly surveyed about 1713, does not show either Greatorex Vein, Bedehouse Vein or the branch level (Chats. Bar. Coll).

The accurate survey carried out by Anthony Tissington in 1777 (SCL, Bag 180) likewise does not refer to it.

From the evidence presented by the plans alone it is reasonable to conclude that the branch level had been abandoned at the barren forefield and was comparatively useless by 1713 at least, otherwise it would have been shown on Hutchinson's plan.

An ambiguous reference may also relate to the Greatorex level. An undated 18th century document discussing mining customs with particular relevance to soughing observed:

> "this (Cromford Sough) was begun at a place called Crumford Moor ..... at the expense of near £20,000 for carrying on the Sough so vast a way thro' Rocks of limestone which cud not be worked but by boreing holes and blasting with Gunpoweder some times at £20 a fathom and more, the same was both chargeable and delatory and great obstructions were occasioned by the want of wind in the Sough, which caused Damps and killed the Miners and to carry on the Sough they were forced very often to sink Pitts or Shafts at the expense of £100 or £200 a shaft to give wind to the Sough". (Woolley, 6681 f196).

The document continues by outlining the history of Cromford Sough including the sale of shares in the sough by the original partners (in 1687-88) and the discovery of the double drift system of ventilation in 1706-1709. The reference to blasting may relate to that part of the sough between Dun Rake and Tinley Vein but the documentary combination relating both to blasting and shaft sinking suggests earlier work at the sough, therefore pre-1680, as no shafts are known on the Dun Rake - Tinley Vein section.

The main sough southwards from the Greatorex Vein branch was continued by the original partnership and the eventual connection with Dun Rake was probably made about 1680. These partners sold out to the Earl of Yarmouth in 1687-88; in turn he sold out to Francis Gell in 1693. The connection with Tinley Vein was completed by 1696 (Flindall, 1974).

CONCLUSIONS

The preceeding suppositions, if correct, strongly imply that the Greatorex-Bedehouse Vein branch sough was constructed in 1676 and was probably an abortive attempt to unwater the contemporary inferred southeastwardly continuation of Rose Rake. The position of the branch level, some feet above the main sough suggest that it may be an unmodified remnant of the pre-1706 sough. That portion of the sough recorded as driving in a hard vein in 1676 cannot be

realistically assigned at such an early date to anything other than the section of the branch level driven along the thin scrin. This apparently insignificant passage therefore displays the earliest visible gunpowder work in a mine anywhere in Britain.

The type of shot hole stemming is also important historically. Tradition claims that stone dust and clay plugs replaced the original iron wedges but was not introduced into this country from Germany until considerably later than 1687, having been used initially in the mines of the Harz.

The stone dust and clay stemming used in Cromford Sough is therefore very probably older than the German example by a decade, the use of iron wedges in Derbyshire lead mines being either very early and very limited in application, or more likely the two methods were in use concurrently. The reference to a man killed by plug and wing at an Eyam mine in 1699 suggests the latter.

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Finally, thanks are due to Miss J. Dudley at the Royal Greenwich Observatory for kindly supplying me with a complete set of xerox copies of the Dovegang Mine accounts.

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RGO 33 Royal Greenwich Observatory, Flamsteed MSS
Soc. of Gen. Heath. Society of Geneologists, Heath Papers, extracted from the records of the late Nellie Kirkham, courtesy of D.Nash.
Chats. Bar Coll. Collection of uncatalogued books, documents and plans in the Barmasters Collection, Chatsworth House.
SCL Bag.Coll. Sheffield City Libraries Local History Dept. Bagshawe Collection.
SCL OD Sheffield City Libraries Local History Dept. Oakes Deeds.

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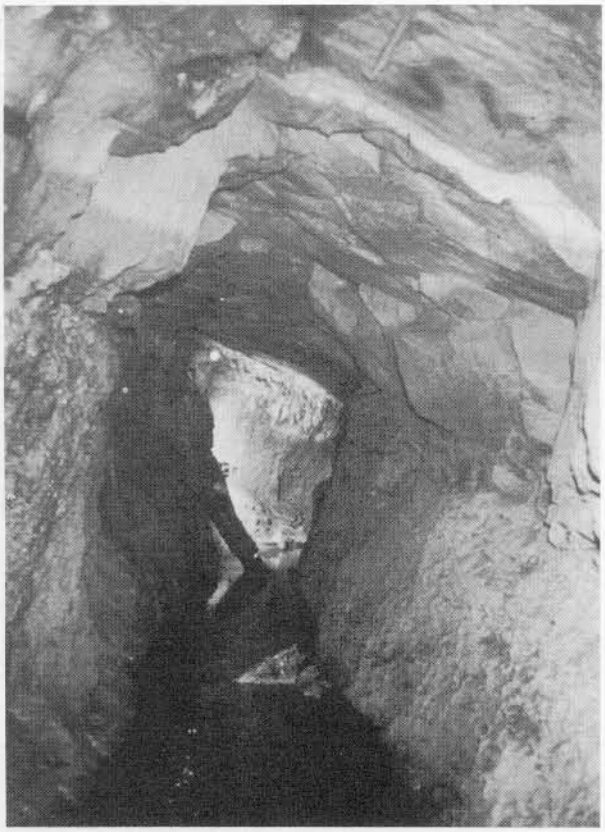
Revised MS received 21st Dec. 1982.

PHOTOGRAPHS TO ACCOMPANY J.H.RIEUWERTS' ARTICLE ON CROMFORD SOUGH
PUBLISHED IN THE BULLETIN Volume 8 No.5

1. The tail of Cromford Sough today.

2. Typical section with picked top section in shale, limestone bed across the middle and shale below in the footings.



3. Section with limestone bed in the roof and shale walls. Scattered shot holes in the roof; picked shale walls.

4. Shot-holes in the Greatorex-Bedehouse branch level - probably the earliest mining shot-holes still accessible in Britain.