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Ayton Banks Alum Works North Yorkshire

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SURVEY REPORT

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Ayton Banks Alum Works,

GREAT AYTON, NORTH YORKSHIRE

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County:	North Yorkshire
District:	Hambleton
Parish:	Great Ayton
NGR:	NZ 5888 1077
NMR No:	NZ 51 SE 60
SAM/ RSM No:	31343
Date of survey:	March 2004
Surveyed by:	Trevor Pearson, Abby Hunt and members of the Great Ayton Community Archaeology Project
Report author:	Trevor Pearson and Abby Hunt
Illustrations by:	Trevor Pearson
Photography by:	Trevor Pearson

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CONTENTS

LIST OF ILLUSTRATIONS

1. INTRODUCTION

In March 2004 a team from the York office of English Heritage assisted members of the Great Ayton Community Archaeology Project to survey the remains of Ayton Banks Alum Works (also known as Cockshaw Hill Alum Works) 3 km to the east of Great Ayton village centre (NGR NZ 5888 1077). The site is legally protected as a scheduled ancient monument (RSM 31343) and has the National Monuments Record number of NZ 51 SE 60.

The results of the survey will feed into the project group's research into the archaeology and landscape of the two parishes of Great and Little Ayton for which funding has come from the Local Heritage Initiative grant scheme administered by the Heritage Lottery Fund. The results also complement recent surveys of alum working sites in the region undertaken by the York office of English Heritage. These include the coastal sites at Kettleness and Loftus (Jecock *et al*, 2003; Hunt *et al,* 2004).

The survey encompassed the alum quarry and the area immediately to its west where the initial processing of the alum shale took place. The boiling house, where the final processing took place, has yet to be definitely located but it probably stood some distance downhill from the quarry site. The background research for this report was restricted to readily available secondary sources as primary research is being undertaken by members of the Community Archaeology Project.

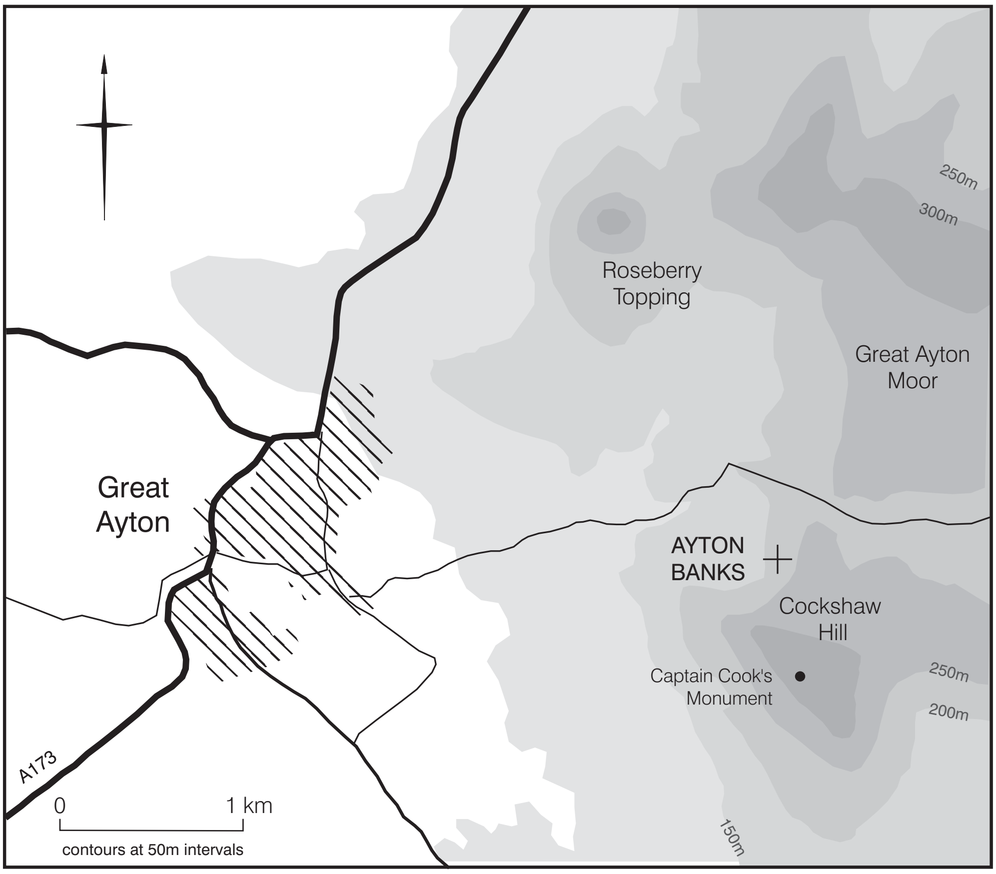

Figure 1.
The location of the site

2. GEOLOGY, TOPOGRAPHY AND LAND-USE

The site is on the west side of Cockshaw Hill at an elevation of between 200 and 250 metres above Ordnance Datum. The hill is formed from upper lias strata of the Jurassic period and has been worked for ironstone, jet and building stone as well as for alum. The exploitation of the ironstone and jet rocks has left extensive workings towards the bottom of the hill whilst the alum is contained in beds of shale which outcrop towards the summit. Above the alum shales is a bed of sandstone which has been quarried for building material.

The steeply-sloping quarry face left by the extraction of the alum shale is around 25m high and extends for a distance of 100m along the hilltop. Remains connected with the processing of the quarried shale begin at the foot of the quarry face and extend for a distance of up to 85m westwards. The area is quite extensively overgrown with bracken which obscures most of the site during the summer months. Several footpaths cross the site whilst the well-used route to Captain Cook's memorial on the summit of Easby Moor passes close to the eastern edge of the quarry.

3. HISTORY OF THE SITE

The period during the Seven Years War with France, which ended in 1763, had seen the price of alum fall to a low level. In the aftermath of the war the price began to recover, and it appears that the alum works at Ayton Banks was opened in 1765 to take advantage of this. However, the works were short-lived, only lasting for six years (Pickles 2002, 15). It was not uncommon for works to close for extended periods of time, often at times when demand was low and, therefore, prices fell, but then to leter reopen when the market was more buoyant. However, no attempt appears to have been made to re-open the Ayton Banks works. This is supported by the field remains which do not show the same multiplication of features such as spoil tips, calcining places and track-ways evident at the longer-lived sites. The First Edition 1:10 560 Ordnance Survey map of 1856 labels the site as 'old alum quarry' (Ordnance Survey 1856) but this and later Ordnance Survey maps at a scale of 1:2 500 do not depict the remains in any great detail (Ordnance Survey 1894a and b; Ordnance Survey 1915a and b). The 1856 map labels the sandstone quarry above the alum workings suggesting it was being actively worked at the time the map was surveyed.

4. DESCRIPTION

The process of alum manufacture has been discussed at length in recent publications (Rout 2002). Generally, the technique is fairly well understood, but despite a reasonably high level of research, there are still many questions over the specifics of some stages in the process. From the various contemporary accounts it appears that the process of alum making was not absolutely standardised, with each site adapting the various stages to their own resources and restrictions. In addition, the industry evolved over time, changing and improving as technological knowledge improved. The process of alum manufacture was not a quick one, and it could take up to one year from the time that the shales were extracted to the finished product leaving the site (Almond 1975, 11).

4.1 Quarrying

Perhaps the simplest stage, in technological terms, of the alum making process was to obtain the raw alum-bearing shale. The initial step was to remove the sandstone capping, or overburden. The shale below is quite soft and friable and therefore relatively easily dislodged. The quarrying could thus be undertaken with iron picks, with the quarried shale being transferred to a wheelbarrow for movement to other parts of the site (Almond 1975, 11). This activity was labour intensive and would have required a lot of unskilled labour to hew the shale from the quarry face and barrow it away. Contemporary evidence, both written and pictorial, has informed current thinking that the quarries were worked in broad terraces, progressively enlarging and deepening the quarry and thus giving the site a stepped profile.

At Ayton Banks, the alum quarry is around 25m deep, 130m across and cuts up to 70m into the side of the hill. A slight step around 10m above the bottom of the quarry indicates where the ground was lowered below the main level of the alum-bearing shale in order to create a calcining area. The calcining area was a level base well below the main seam of alum-bearing shale on which the clamps of quarried shale were built and fired (see below). Later extraction of the overlying sandstone has resulted in a second parallel quarry face some 10m high and 25m back from the top edge of the main alum quarry. Excluding the lower cut for the calcining area, the dimensions of the quarry indicate that about 100,000 cubic metres of shale was dug out of the ground during the six year working life of the site. However, only a proportion of this would have been sufficently rich in alum to warrant processing.

A short length of drystone walling (see Figure 2) about two-thirds of the way up the north side of the quarry probably indicates that this side was faced with a revetment wall to stop loose shale falling onto the steeping pits and calcining area below. Better preserved lengths of revetment wall survive at some of the coastal sites, most notably at Boulby, to the north of Whitby, where they have been partially restored. It would also have made sense, for the same reason, to have faced the south side of the quarry with stone, but no trace of any walling was noted.

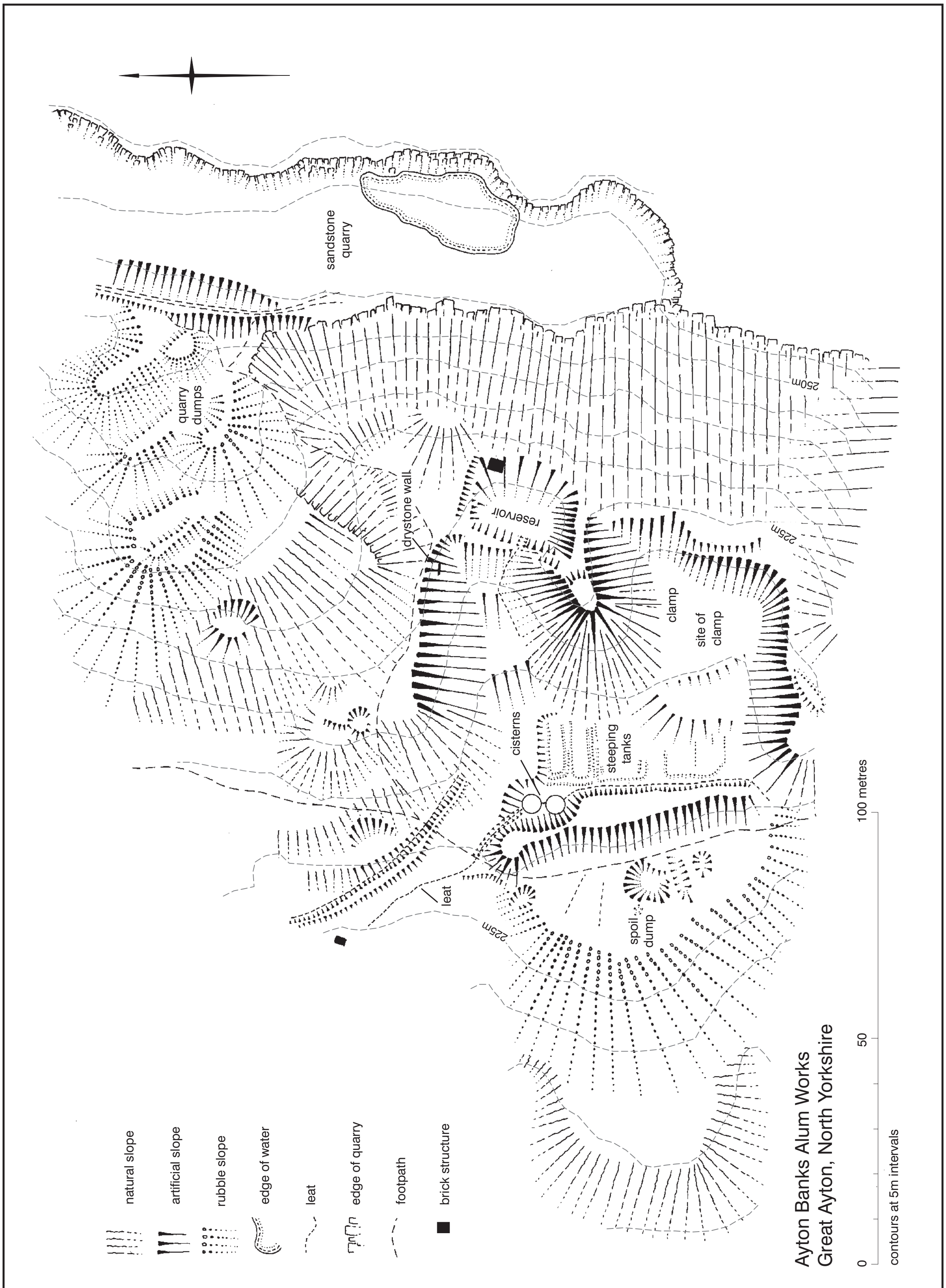

Figure 1. English Heritage survey plan reduced from 1:1000 scale original

Spoil from quarrying and other waste from processing the alum-bearing shale was tipped to the west to form a massive embankment on the hillside directly beyond the quarry. This is up to 15m high and has been engineered so that the level top is at the same height as the calcining floor to the east, suggesting there were plans to extend the working area in this direction. However, the usefulness of this area is limited because a high bank along the east side of the spoil heap divides it from the calcining area. There are several slight sub-rectangular and circular hollows on the surface of the main spoil heap which are difficult to interpret but may suggest it was used as part of the working area before the construction of the bank. Several slight furrows in this same area could indicate where the quarry spoil was barrowed to the edge of the mound.

4.2 Calcining

Although the alum-bearing shales are relatively soft and friable in their raw state, further treatment was required to render the aluminium sulphate, present in the shale, soluble in water. This was achieved by burning, or calcining, the shale. The burning occurred in large piles, or clamps, made up of alum shale placed on a layer of fuel, usually brushwood. A contemporary witness described how the clamps were built to a height of 4 feet (c 1.2m), ignited, and then further piles of alum were added until the clamp was as much as 100 feet (c 30.5m) high and up to 200 feet (c 61m) in length (Young 1817, 812). The ignition of the clamps had to begin before they reached too great a height otherwise the flow of air would have become constricted, thus impeding the combustion of the material. The clamps were left to burn for a considerable length of time, a matter of months rather than days. It was necessary to maintain a steady level of combustion within the clamp, and this was often achieved by covering any gaps with a layer of damp shale. Weather conditions, such as high winds, could result in the fire burning too fiercely. The clamp was allowed to cool over a period of months, during which time, chemical reactions were still occurring, enriching the amount of aluminium sulphate present. Young (1817, 812) observed that the clamps and the resulting alum were often '8 or 9 months in forming'. One of the few known depictions of a functioning alum works is a watercolour of 1843 by H B Carter, which shows two large calcining clamps smouldering in the foreground of the painting (reproduced in Miller (ed) 2002, rear cover and inside front cover).

There is a single, very well-preserved clamp surviving at Ayton Banks close to the foot of the main quarry face. It is a conical, bracken covered mound 10m high with a narrow ridge of possible *in situ* alum-bearing shale on its east side which might have been kept to run barrows from the quarry face onto the mound. This ridge also helps define the south side of the reservoir supplying water to the workings. Exposures of burnt shale on the surface of the mound strongly suggest that the feature is a clamp that has been abandoned after firing and is therefore a very rare survival. Most of the mounds interpreted as clamps at other alum sites in the region are more often than not just heaps of quarry waste, for example at Kettleness (Jecock *et al* 2004, 33).

The mound at Ayton Banks partly overlies a level area immediately to the south which may be the base of an earlier, dismantled clamp whilst on the north-east, the side of the mound impinges upon the exterior face and the top of a dam. The latter forms the reservoir pond for supplying the steeping tanks situated lower down the slope (see below).

4.3 Steeping

On completion of the calcining process, the burnt clamps were finally dismantled and the calcined shale was transported, again via barrows, to steeping pits filled with water, where the soluble salts were dissolved out. The liquid resulting from this process was known as alum liquor. In order to achieve as saturated a solution as possible, it is believed that burnt shale was generally washed several times. This multiple-stage, counter-current process has been discussed and examined in some detail by Rout (2002, 21-23). The actual number of stages in this process would probably have varied through time and at different works. The steeping pits may have been built without any covering, a situation that would have been advantageous in hot weather, when evaporation was aided, but conversely, rainy weather would have diluted the liquor. However, evidence at Kettleness suggests that a lip along the inner edge of a tank would have housed some kind of cover (Jecock *et al* 2003, 45). This process would have necessitated the transference of liquor or shale between tanks. Pumps were utilised to move the liquor, a fact that is confirmed by the inclusion of '10 pumps' in a 1684 inventory of the alum works at Lingberry Hill (Hunt *et al* 2004, 22).

At Ayton Banks, there are the remains of possibly as many as six steeping tanks organised in a north-south line visible as a series of slight, rectangular mounds. One explanation of why the tanks are represented by slight mounds rather than the depressions seen at other sites is that they were abandoned when full of calcined shale. However, it seems unlikely that the shale was mounded up in the tanks as this would have hindered the steeping process. The division between the third and fourth pits from the north is not visible on the surface and it is conceivable that there is just one steeping tank here, double the size of the others. The base of the mound of the clamp described above impinges upon the east side of two of the tanks possibly as a result of erosion off the side of the mound after the site was abandoned. The two most southerly steeping tanks are also partly obscured, presumably by a layer of spoil. The flat-topped, 2m high bank referred to earlier may have been constructed in order to shelter both the west side of the row of tanks and also the pair of circular stone cisterns to their north. The leat which connects the west side of each of the tanks to the cisterns cuts into the bottom of the bank indicating that the bank is earlier than the leat.

4.4 Water supply

Steeping required each alum works to have a large and reliable supply of fresh water. Because demand was periodic, reservoirs or holding ponds were often constructed to store water collected from local springs and streams. There has been little or no discussion in the archaeological literature of how water was actually conveyed from the reservoirs to the pits, possibly reflecting the rarity of survival of significant evidence.

At Ayton Banks, the reservoir occupies a ledge within the alum quarry above the cut for the calcining area and consists of a sub-rectangular hollow with the dam (referred to briefly above) on the western, down-slope side. The hollow measures some 22m north-south and is 16m across at the top and has quite gently sloping sides. It was presumably fed by the spring shown on the First Edition Ordnance Survey map higher up the hill. The dam has an internal height of just over 1m and, as there is no stone visible in the make-up, it is probably of earth construction. The outfall from the reservoir is via a cut in the top of the dam from where a leat is traceable as a slight channel extending down the slope below the dam and heading towards the north end of the row of steeping tanks described above. There is no trace surviving in this cut of a stone conduit leading from the reservoir, as has been recorded at several other sites, for example at Kettleness (Jecock *et al* 2004, 47). A conduit is likely to have existed originally, and one can only presume that the stones have been robbed out. At this point the flow would have been engineered to feed each of the tanks as required. In its course down the slope, the leat passes very close to the foot of the clamp; so close in fact that there must have been the danger of material rolling down the clamp and blocking the leat. However the apparent proximity of these two features is probably illusory and results from the slippage of material down the side of the clamp following the abandonment of the alum works.

4.5 Settling

Once concentrated, the alum liquor was run, or pumped, off via stone troughs into one or more settling tanks or cisterns in order to allow fine shale particles and other solid impurities to fall out of suspension. It was then transferred to the alum house. The settling cisterns tended to be built in pairs, as is the case at Ayton Banks. Evidence also suggests that they were covered with wooden boards to protect the liquor from rain and further contamination. Once the liquor had clarified in the cisterns at alum works it was usually conveyed to the alum house in a trough, often made of wood, or possibly through lead pipes. Gravity was used to enable the conveyance of the alum liquor from the cisterns to the alum house, which may often have been situated some distance away from the quarries and settling tanks, for reasons discussed below. In some cases, therefore, the trough extended over a considerable distance, crossing difficult, uneven terrain.

As was mentioned above, a leat on the west side of the steeping tanks fed the alum liquor from these tanks northwards into an adjacent pair of circular, stone-lined cisterns. These are the only masonry features on the site to have survived reasonably intact, measuring 4m in diameter and about 1m deep, with four courses of good quality masonry surviving. They are protected to the west by the bank mentioned above. The field evidence is that the bank was constructed around the cisterns, rather than the cisterns being cut into the side of the bank. A broad and initially quite deeply-cut channel heads north-westwards from the northern of the two cisterns taking the processed alum liquor on to the alum house, the location of which has yet to be definitely identified. The leat is traceable for a distance of 16m as a steep-sided cut after which its exact course is difficult to trace in the disturbed ground associated with later jet workings. There is a well-preserved channel with an upcast bank on the downhill side on the slope immediately above this leat. This second channel is probably an overflow or bypass channel from the reservoir pond. It is certainly at too high a level to have had a role in the movement of alum liquor from the cisterns. The feature is 40m long and starts some 50m to the west of the reservoir. From this point back to the reservoir it presumably consisted of a wooden trough built on the natural slope, but this has left no earthwork traces. In the opposite direction, the bypass channel drained away down the natural slope but, again, any evidence of its course has been destroyed in this area by the later jet workings.

4.6 The Alum House

The remaining processes, namely concentration, crystallization and washing, all took place in the alum house. The alum liquor was mixed with a proportion of previously concentrated liquor (known as 'mothers') before being further concentrated by boiling off the water in lead-lined pans until it had reached a certain specific gravity. At this stage either burnt kelp (to provide potassium sulphate) or urine (ammonium sulphate) was added. Urine was more commonly used up until the mid-18th century, but this was superseded by the use of burnt kelp, which was itself soon supplanted by the use of muriate of potash (potassium chloride). The liquor was decanted from the settlers into wooden tubs, where it was allowed to cool over a number of days. As it cooled, it crystallised on the sides and floors of the tubs. Any solution remaining in the tub was then collected and recycled into the process as 'mothers'. The alum crystals at this stage still contained impurities and may have been brownish in colour. To remove these final impurities, the crystals were washed or roached, that is, redissolved in hot water and the resulting solution run off into casks (or 'roaching tuns') to cool and recrystallise. After about 16 days, the tuns were dismantled to reveal a solid crystalline block with a liquid centre. The block was then drilled to allow the remaining water to run out before being sawn up and ground down into powder.

The production of alum required large quantities of heavy and/or bulky raw materials, such as coal and alkali, which had to be brought in. This meant that transport links were of great importance when considering the location of the alum house. At the time of the survey the location of the alum house was thought to be indicated by a group of earthworks in a pasture field 500m to the west at the bottom of the hill next to Dykes Lane. The lane heads westwards into the centre of Great Ayton village. However this location awaits investigation and other locations are also possible.

4.7 Later features

The existence of later jet and ironstone workings immediately below the site has already been mentioned. Also the sandstone at the top of the site, initially removed as overburden during the quarrying of the alum shale, was worked in its own right after the abandonment of the alum quarry resulting in a secondary quarry face above the main alum quarry. This secondary quarry face extends further north than the main alum workings and has left several quite prominent mounds of stone waste on the natural slope immediately to the north of the alum quarry. While it is conceivable that some of this spoil dates back to the period of the alum works, it is more likely that these dumps are connected with the later quarrying of the sandstone. This is supported by the observation that the most southerly of the spoil heaps overrides the north side of the alum quarry. There are several other minor and undated surface quarries on the natural slope below these spoil heaps.

The only other recent feature of note is a brick-built, roofed cistern at the foot of the main alum quarry which was presumably constructed to improve the management of the spring water. There is a second brick tank or cistern 110m to the west on the approximate line of the leat described earlier which connected the workings to the alum house.

5. DISCUSSION

The fieldwork at Ayton Banks has built on the initial survey work undertaken by the Great Ayton Community Archaeological Project and has produced the first detailed record and analysis of the alum workings. Ayton Banks is unusual for the clarity with which the initial stages of alum production can be followed on the ground and also for the compact size of the site. Because the other sites in the region had longer lives, they now present far more complicated and sprawling landscapes of mounds and quarries. This makes it difficult to identify separate phases of operation, certainly ones as short as the six years in evidence at Ayton Banks. What is easy to appreciate here more than at the other alum works is the organisation that went into laying out the workings. This is evident in the way the clamps, the steeping tanks, the reservoir and the cisterns were all neatly accommodated in a small area and the waste tidily disposed of to the west. The evidence that the sides of the quarry were probably revetted with drystone walling adds to this impression of a highly organised operation. The site is also more complete than most of those on the coast where the action of the sea and cliff slips have destroyed evidence of the workings (Jecock *et al* 2003, 75-6; Hunt *et al* 2004, 17-8).

That the workings did not remain static during the six years of operation can be observed, or at least inferred, from the field remains. For a start, there are the visible remains of at least two clamps, with the earlier having been fully worked out and the later one abandoned still intact after firing. However, it is documented that a clamp could take eight or nine months to burn through, so there might have been as many as eight or nine clamps in this small area during the six year life of the workings. When the quarrying first started, the workings must have been quite differently arranged as there would not have been the space available within the quarry floor to accommodate a clamp, the steeping tanks, the cisterns and the reservoir. No direct indication of an earlier layout was noted, although one possibility is that features have become buried underneath or within the embanked spoil heap on the west side of the quarry. The almost complete absence of masonry on the site suggests the workings have been intensively robbed for stone. This may have been to provide local building material, but it is also possible that some of the worked stone was carted away for use at other alum works in the neighbourhood.

The field survey did not record the surrounding landscape, although it determined that the prominent heaps of sandstone rubble on the north side of the main alum quarry are probably connected with the later stone quarrying, though some might be from the opening of the alum quarry.

In conclusion, Ayton Banks is unique among the alum sites in north-east Yorkshire for the clarity of the remains and because it is part of a wider industrial landscape. It is to be hoped that that the Community Project is successful in locating the alum house to complete the picture of the alum works.

6. SURVEY METHODOLOGY

The survey was carried out within OS National Grid co-ordinates using a Trimble dual-frequency Global Positioning System (GPS). While the base station was logging the satellite data necessary to make the calculation, a second 'roving' receiver (Trimble 5800), working in real-time kinematic mode, was used to record the archaeological features. The resulting data were processed using Trimble Geomatics Office (TGO) software. This was then plotted at 1:1000 via KeyTERRA-FIRMA software. A routine within that software was used to calculate the volume of shale removed by the quarry.

7. ACKNOWLEDGEMENTS

The field survey was undertaken with the help of Liz Greenhalgh, David Taylor, Robert deWardt and Peter Watson, all members of the Great Ayton Community Archaeology Project. Project members Ian Pearce, David Taylor and Robert deWardt are also thanked for discussing various aspects of the survey results; Ian Pearce additionally helped set up the project. Chris Hall of the Scarborough Archaeological and Historical Society also helped in the initial stages of planning the survey. The report has been edited by Chris Dunn, Senior Archaeological Investigator at English Heritage.

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