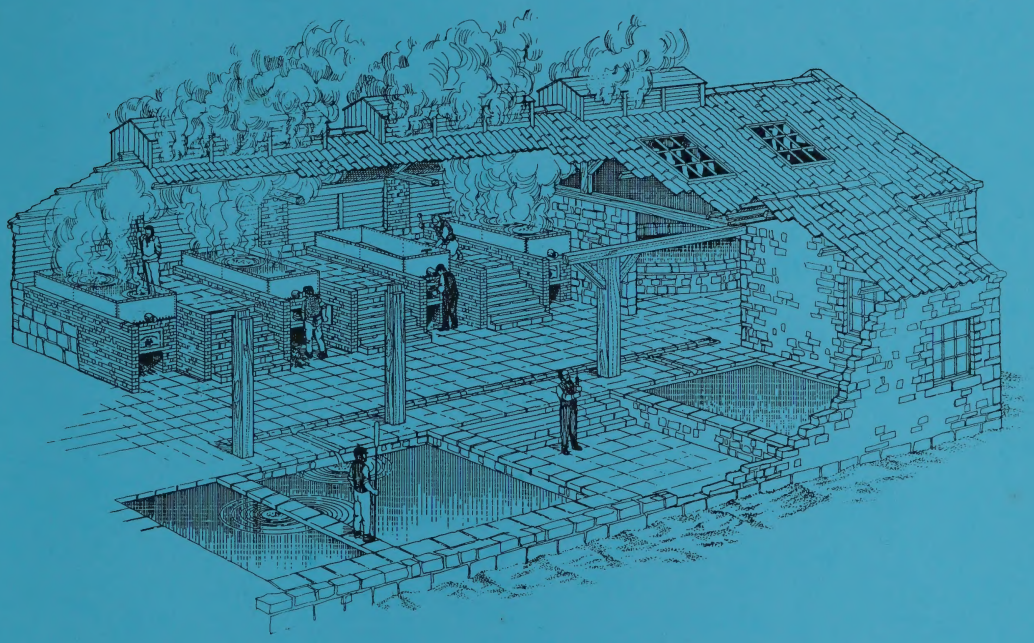
SCARBOROUGH ARCHAEOLOGICAL AND HISTORICAL SOCIETY

SALTWICK ALUM WORKS

AN ARCHAEOLOGICAL INTERPRETATION



GARY MARSHALL

RESEARCH REPORT 11

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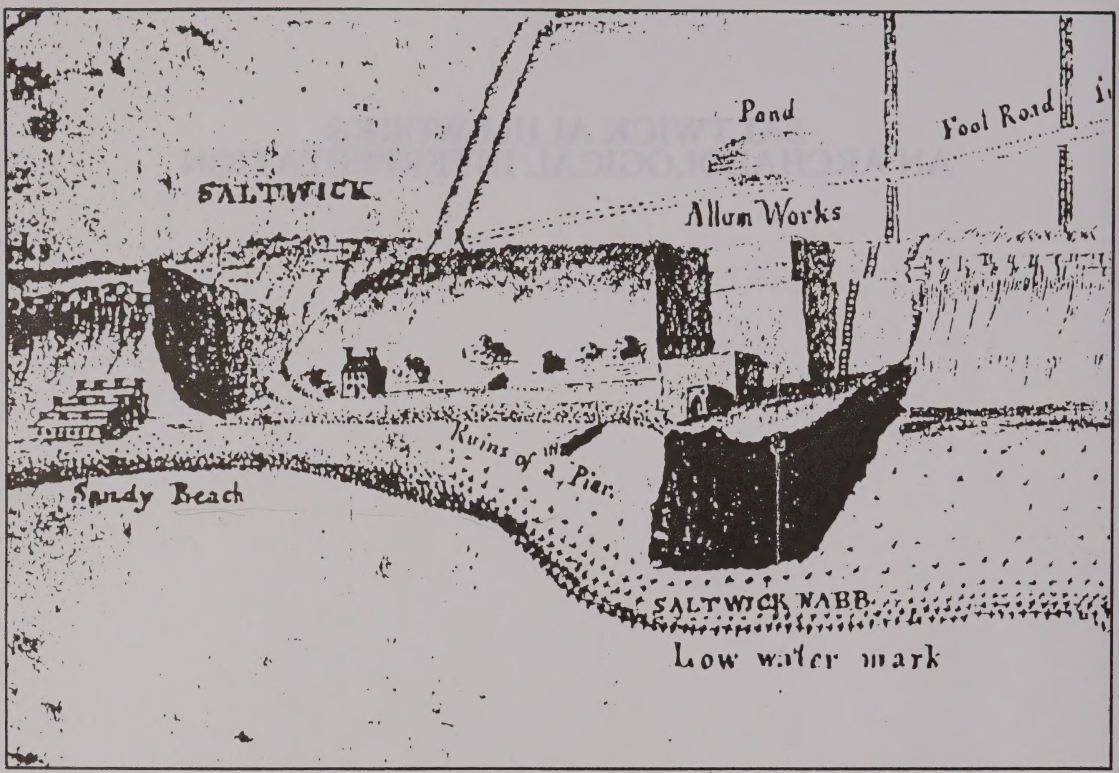

FRONTISPIECE
An extract from Francis Gibson's Plan of the Natural and Artificial Defences around the Port of Whitby

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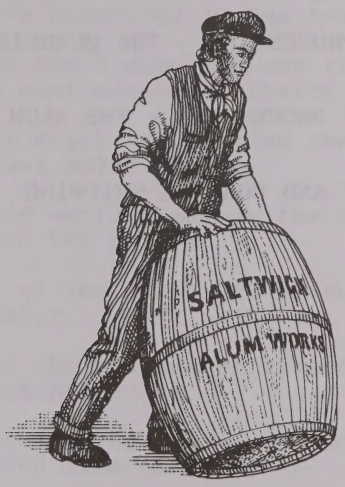

GARY MARSHALL

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PREFACE

During 1990 a number of Members of the Scarborough Archaeological and Historical Society became increasingly concerned about the loss of physical evidence of one of the North Yorkshire coast's most important industries; alum production. As a result those members set up an informal group, The Alum Research Group, to carry out field research and recording.

This report deals with the former Saltwick Alum Works where a research and recording project was undertaken by the Alum Research Group in association with Whitby Research Group in response to the continuing erosion of archaeological evidence dating from the 17th and 18th centuries. Erosion caused by tide and wave action, cliff slumping and to some extent, human interference is affecting all the coastal alum sites of Yorkshire and Cleveland. Saltwick is particularly badly affected as the important industrial archaeological evidence is located here in an extremely marginal coastal environment.

At Saltwick it is no longer possible to preserve the evidence in situ. The aim of the work done here has, therefore, been to record and interpret the evidence, and to allow at least for its preservation by record.

The Saltwick site is one of outstanding importance because of its reliance upon coastal shipping as a means of transport. Sufficient evidence survives to illustrate this close dependence and to suggest that its unusual arrangement is closely determined by the prevailing landscape form. The evaluation combined landscape survey and excavation to assess the archaeological detail and place it in its landscape setting. The project has added to a growing corpus of material relating to Yorkshire's former alum industry, much of it arising from historical documentary research. The emphasis of this evaluation on recording the surviving physical evidence serves to redress this imbalance, and to illustrate aspects of the processes which are not adequately covered by the documentary record.

ACKNOWLEDGEMENTS

The organisation of work in the field, excavation equipment and finance were provided by the Scarborough Archaeological and Historical Society whilst the photographic recording was funded by the Whitby Literary and Philosophical Society. The total station topographical survey was carried out by members of the Alum Research Group using equipment kindly loaned by York Archaeological Trust. Computer processing of the data from this survey was carried out on behalf of the project by York Archaeological Trust, generously grant aided by The North York Moors National Park through its Research Grants for Archaeology scheme. Mark Newman carried out the geophysical survey.

Analysis of plant and invertebrate remains from the alum house cistern was carried out by Allan Hall and Harry Kenward of the Environmental Archaeology Unit, University of York. Jennifer Hillam of Sheffield University Dendrochronology Laboratory examined timbers from the excavated alum house.

The work of The Alum Research Group, particularly the Saltwick Project has benefited from a grant in 1992 from The Robert Kiln Trust and through the David Thubron Memorial Award of CBA Yorkshire and Humberside in 1993.

The success of this project would not have been possible without the commitment and support of a number of individuals who helped carry out the field work, often under appalling combinations of wind and tide. In particular I should like to thank Dorothy Chaplin, Kay Dunderdale, Charles Gavan-Duffy, Chris Hall, Alan Harland, Maggie Horton, Trevor Pearson, John Petty, Adam Russell and Maureen Smith of the Scarborough Archaeological and Historical Society; Janet Green of the Whitby Research Group and Chris Williams and his band of excavators who made the journey over from Harrogate on many occasions. Many of the organisational burdens of the fieldwork were borne by Chris Hall, Field Officer of the Scarborough Archaeological and Historical Society who also read and commented on the draft of the report.

The reconstruction drawing of the interior of the alum house was done by Alan Marshall, whilst other drawings were prepared for publication by Trevor Pearson. Preparation of the text for publication was carried out by Frances Hall.

Francis Gibson's 'Plan of the Natural and Artificial Defences around the Port of Whitby' is reproduced by kind permission of the Public Record Office

Final publication of this report would not have been possible without further financial aid from the Robert Kiln Trust and the North York Moors National Park.

I gratefully acknowledge the help and generosity of all these individuals and organisations.

Gary Marshall

Note on site referencing

The system of site referencing used in this report is specific to the Saltwick project. Features are identified with individual site numbers, starting from 001 and continuing up to 049. These numbers are used to cross reference the text with the landscape plans throughout this report

INTRODUCTION

The site of the Saltwick Alum Works lies within Saltwick Bay (Figure 1 and Plates 1 and 2), about one kilometre east of Whitby on the North Yorkshire coast (centred on grid ref. NZ 917108). Saltwick Bay measures about half-a-mile in length, curving gently from Saltwick Nab on its north-west margin round to Black Nab on its eastern margin (Figure 2). The two 'Nabs' are seaward projections of hard Jurassic alum shale which have resisted the erosive power of the sea, thus affording the interior of the bay a degree of protection from waves driven by prevailing northerly winds. Both of these nabs have been exploited as a source of alum shale, ultimately to produce the raw alum liquor which was then conveyed to the alum house at beach level between the two nabs - probably via timber launders known as 'liquor troughs'.

Saltwick was one of a group of about thirty sites in North-East Yorkshire producing alum. For a period of nearly two hundred years the region held a supreme position, producing almost the entire output of British alum which was used primarily as a mordant in the textile dyeing industry and as a curing agent in the tanning of leather.

The production of alum at Saltwick covers a period of about 150 years, beginning in 1649 when Sir Henry Cholmley, acting on behalf of his exiled brother Sir Hugh Cholmley who was Lord of the Manor of Whitby, entered into a partnership with Sir Richard Crispe to commence production[1]. According to the Reverend George Young production ceased in 1708 and was not resumed until 1755[2]. However, Sir Hugh Cholmley received as compensation the sum of £200 in 1736 for laying idle the Saltwick works[3], implying that there was some output immediately prior to this agreement. In 1764, when there were a total of ten sites in North Yorkshire producing alum, Saltwick was operating three evaporating pans, each with an annual capacity of about 80 tons[4], which in total was slightly less than 10% of the region's output.

Young gives the date for the demise of alum production at Saltwick as 1791, but the site may have continued producing alum until the turn of the 19th century. Francis Gibson's oblique view of the defences around Whitby[5] (Figure 3) dating from the 1780s shows ladders descending into both quarries and seems to suggest that Saltwick was still operating as an on-going concern. The site is otherwise poorly documented. Written sources do suggest however, that Saltwick initially adopted a novel arrangement for producing the alum crystal, shipping its raw liquor to South Shields for evaporation and thereby avoiding the enormous expense involved in bringing Durham coal to fuel the evaporating pans. The award of a licence to Sir Hugh Cholmley to build a harbour in 1673[6] almost certainly relates to the adoption of this novel arrangement.

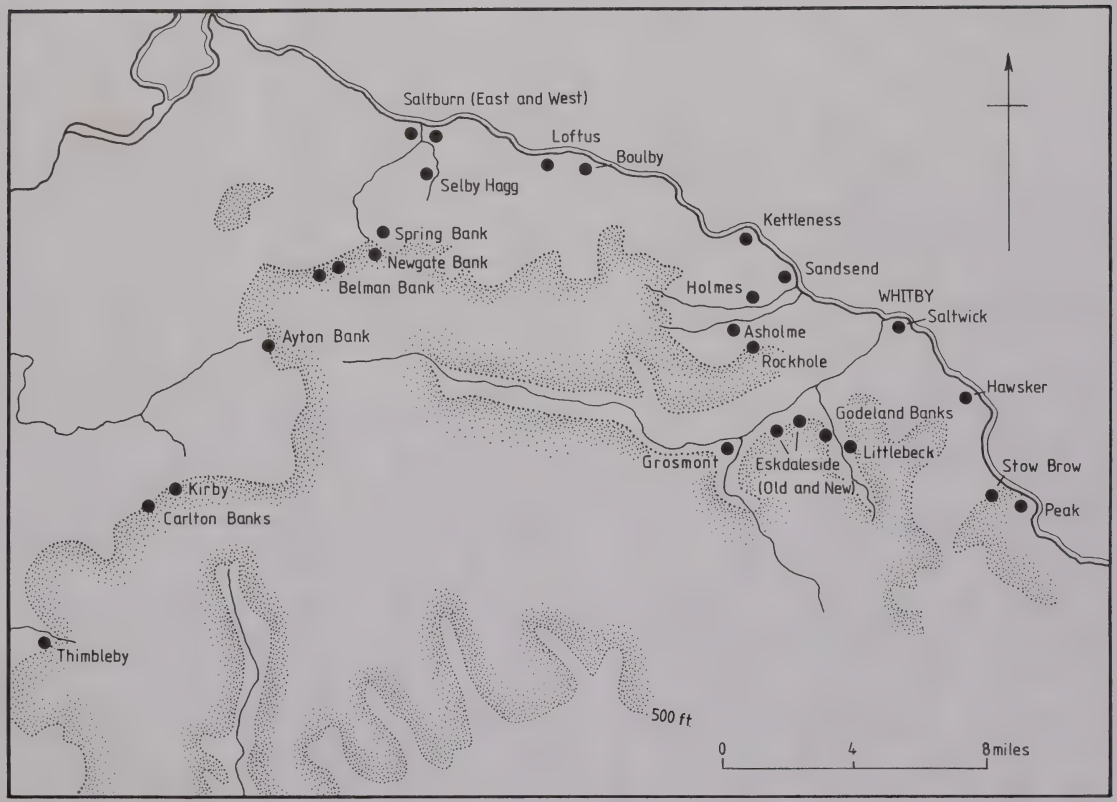

FIGURE 1

Plan showing the location of former alum works in North-East Yorkshire

The whole arrangement and its attendant advantages is described in William Watson's useful account of the Guisborough alum works dating from the 1850s.

> *"From Saltwick the alum liquor was conveyed to Shields in vessels constructed for the purpose, when an alum house was erected, generally known now as the same site of ground, and named 'Alum House Ham'. The freight of the liquor to Shields, it was apprehended, would be less than the freight of coals from thence to Saltwick, and the coals used at Shields paid no duty; besides urine was procured at Shields on more moderate terms, and also kelp was laid down something under the cost at the works in Yorkshire. However, this practice was discontinued in the year 1770, a new alum house having been previously built at Saltwick."*[7]

The surviving remains of Saltwick's former alum industry constitute not a single site, but rather a collection of dispersed features within a landscape partially fashioned by past industrial activity. This was appreciated at an early stage of the evaluation and a total station topographical survey of the landscape was therefore carried out as a first step towards recording this evidence (Figures 2 and 4,5,6). Step two of the evaluation involved the excavation of the beach level alum house where the loss of evidence as a consequence of erosion was seen to be most acute. The third step of the evaluation concentrated upon gathering descriptive data to record the dispersed features within the landscape. This descriptive record is supported by a photographic record.

The aim of this report is to present a summary of the evidence resulting from the excavation, as well as a summary of the descriptive data, supported by the landscape plans created in step one. It is arranged thematically, in a logical sequence which describes and interprets the evidence according to the successive stages involved in the production of the alum crystal, beginning with the production of alum liquor in the quarries. Evidence from the alum house excavation is then considered, and finally evidence relating to the import of raw materials and the export of finished alum. Impressive evidence survives to illustrate the latter theme in the form of a substantial harbour and breakwater, nearly 300 metres in length, which suggests that the Cholmleys made a considerable capital commitment towards the efficient operation of the Saltwick alum works. The final section of the report is the discussion and interpretation of the various strands of evidence, which taken together confirm the significance of landscape setting and its influence upon Saltwick's adoption of a novel arrangement for the production of alum.

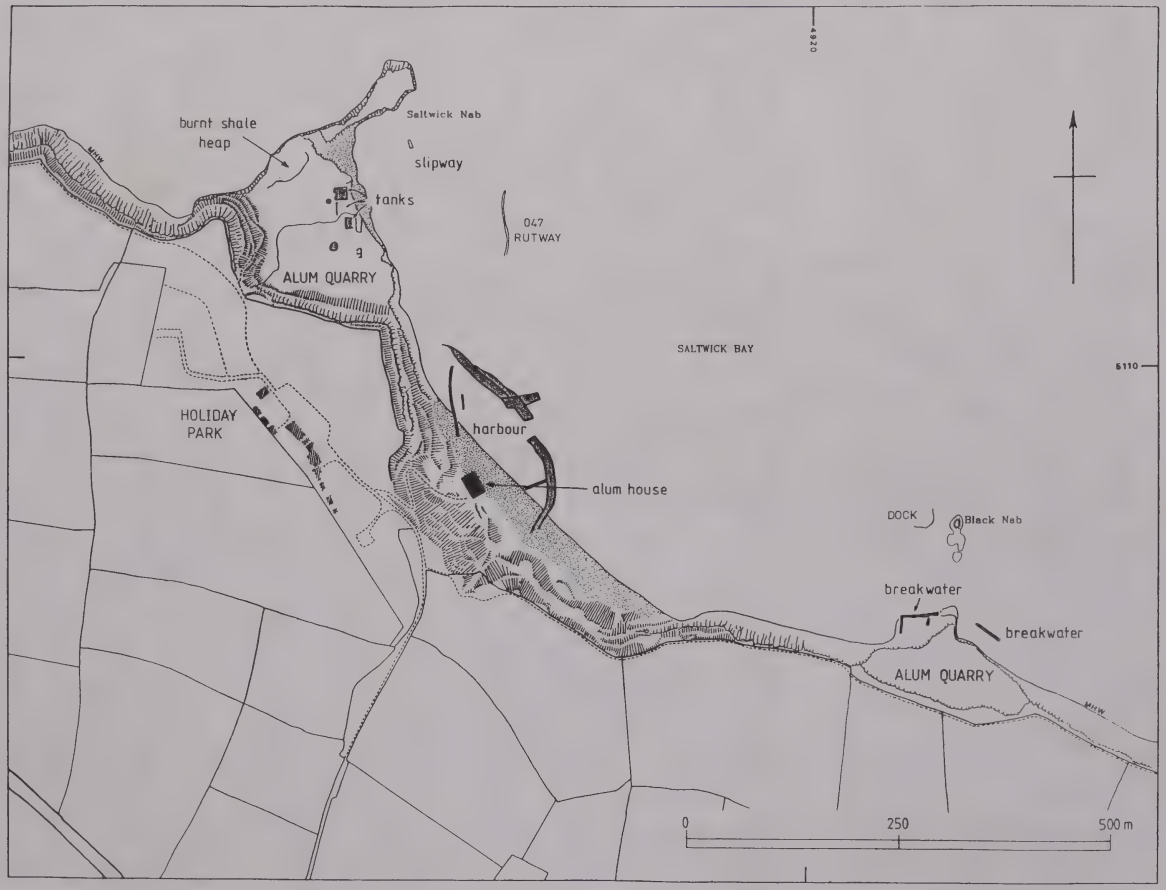

FIGURE 2

Plan of Saltwick Bay showing the location of features relating to the alum works

PLATE 1 *View looking north-west across Saltwick Bay. The remains of the alum house breakwater (023) lie in the centre of the picture. Saltwick Nab appears top right*

PLATE 2 *Looking down on to Black Nab quarry with the west section of the breakwater (034) in the centre of the picture. The Black Nab dock (036) can be seen just to the left of the Nab*

EVIDENCE OF PRIMARY PROCESSING - THE QUARRIES

SALTWICK NAB QUARRY

Saltwick Nab (site reference 001 - Figures 2 and 3) is the larger and probably earlier of the two quarries, developed on a triangular-shaped projection of resistant alum shale. The tip of the projection or the 'Nab' extends for a distance of about 120 metres in a north-easterly direction, although it has been breached in two places (reputedly during the 1953 storms). During the lifetime of the alum works, the Nab afforded protection to ships moored within the bay from waves driven by the prevailing northerly winds. The top surface of the innermost section of the nab is still partly covered with red shale derived from the base of a 'calcining clamp' within the main quarry (Site reference 002), and this suggests that the projection previously formed part of the main quarry.

The main direction of quarrying has been southerly, creating a working face up to 180 metres in length and approximately 35 metres in depth (Figure 3). The upper part of this face consists of 15 metres depth of overburden, comprising beds of clay, shale and 'dogger' sandstone. The remaining lower portion of the face has therefore exploited the grey alum shale to a depth of about 20 metres, although much of the lower part of the face is concealed by collapsed overburden and shale which has formed a broad bank at the base of the quarry (Site reference 003). Gibson's view, though sketchy, shows the main face of the quarry separated into two sections, each divided into an upper and and a lower terrace. The inclusion of the long ladders is particularly interesting since these suggest that the northern half of the quarry was still providing a source of alum shale in the 1780s. On this plan the base of the south-east corner of the quarry has been left in place to provide protection from wave erosion. Attached to the face of this projection is a structure which appears to be vaulted. This is possibly the face of a kiln for burning seaweed to provide potash, subsequently used as an alkali in the alum house. Alternatively it could be the remains of a warehouse since it lies close to the 'Ruins of a Pier' shown on the plan.

The west edge of Saltwick Nab quarry has also been exploited and this probably corresponds with the cut containing the ladders shown on Gibson's view. Only the south-west corner of this west face remains since a combination of quarrying and erosion has removed its northerly continuation towards the more resistant seaward projection. The profile of the quarry rises markedly from the floor towards the north edge where the top surface is covered by a shallow cap of burnt red shale (Site reference 002). The compact nature of this deposit suggests that this is the remains of the base of a calcining clamp, and probably the parent body of the material noted on the nearest detached section of the resistant projection.

After quarrying of the grey alum shale 'calcination' was the next stage in the sequence of primary processing. Calcination

FIGURE 3 *Plan of Saltwick Nab alum quarry, showing features described in the text*

of the shale created weak sulphuric acid within the clamp which in turn acted on the aluminium sulphate in the shale, converting it to a soluble form. The clamp consisted of successive layers of quarried shale built up over a bed of brushwood, which was then ignited. Coal was possibly placed in thin beds between the shale layers, although it is more likely that the natural bitumen content of the shale kept the clamp burning. The clamp was allowed to burn slowly for a period of up to a year, and in so doing the shale assumed a characteristic brick red colour. The presence of this red shale in situ in the quarry is an interesting survival because it indicates the point at which alum shale was last calcined, possibly supplied from a working face in the south-west corner of the quarry.

Evidence for the subsequent stage of 'steeping' the calcined shale to produce the raw alum liquor can be found in the base of the quarry. 'Steeping' - described as the 'watery ordeal' by one observer[8] - involved washing the calcined shale with water in stone-lined pits to draw out the aluminium sulphate as a solution, referred to as 'raw alum liquor'. Gibson's view shows a pond immediately above the quarry, which almost certainly provided a source of water for the steeping process. Waterlogged ground at the base of an alum quarry usually indicates the presence of buried steeping pits and in the Saltwick quarry these are to be found on the east edge, furthest from the quarry face. This is perhaps not surprising since this is the point where quarrying would commence, and hence the first point where there was a terrace available for erecting the pits. The north-west corner of the pits (004) has been exposed as a consequence of erosion cutting into their east wall over a length of about 6 metres. This has also removed part of the north wall so that it is possible to see a representative section through the construction of the pits.

A bed of yellow puddled clay 0.43 metres in depth forms the base of the pit and the whole structure is laid into a shallow vertical cut in the grey shale forming the floor of the quarry. A line of coursed stones overlying the east edge of the clay is the surviving remnant of the east wall, which has otherwise been eroded away. Erosion has also removed evidence of the north wall but this was almost certainly formed of coursed masonry, otherwise the contents of the pit would seep into the surrounding shale. The exposed section showed no evidence of a flagstone floor laid over the clay base, although probing with the metal tip of a ranging rod encountered a solid base in several places at a depth of about 0.5 metres below the turf surface.

The usual arrangement was for the steeping pit to be laid out as a single long range with cross walls dividing it widthways into a series of separate small pits. Documentary sources suggest some variation in the size of these pits but the average dimension would be about 50 feet in length (15 metres), 15-20 feet wide (4.5-6 metres) and 2 feet in depth (0.6 metres)[9]. The depth might increase to 2½ feet at one end (0.76

metres) to give a slope to the floor and improve drainage. It is difficult to measure the dimensions of the Saltwick pits since they are only really visible as a sunken outline in the turf. This sunken outline forms a clear continuation of the north wall, which can therefore be measured over a length of 16 metres before it forms a right-angled return to the south. This return probably corresponds with the west wall of the pits but can only be traced over a length of about 15 metres before it fades out as a distinct edge. However, there is a well defined turf edge close to the remains of the former Tea House (006) which may mark the south edge of the Saltwick range, suggesting an overall length of about 80 metres, divided into as many as 15 pits.

Approximately midway along this length there is a rectangular depression (005) close to the cliff edge which suggests the presence of a second group of pits backing onto the range previously described. Erosion has removed the east side of this depression and as a consequence has exposed a thick bed of yellow clay, which is almost certainly the base of a separate pit not attached to the former range. Erosion has also exposed a short length of masonry in the north-east corner of the depression and this is most likely to be the north wall of the pit.

There are two roughly circular features on the west edge of the pits which may be sunken cisterns for storing the raw liquor before it was run down to the alum house. The southern cistern (007) can be seen as an area of raised turf with a diameter of about 10 metres which is ringed by a profuse growth of vegetation during the summer. It can therefore be detected as a type of cropmark feature, and is best seen from the top west edge of the quarry. The northern cistern (008) is defined by a semi-circular area of standing water, which suggests an approximate diameter of 5 metres.

The identification of these features as cisterns is rather tentative, especially as the ground forming the base of the quarry is so uneven. However, similar circular raw liquor cisterns can be seen in the Boulby and Loftus alum quarries (NZ 752196 and NZ 734200), hence there is a strong possibility that similar circular cisterns were associated with the Saltwick pits. In fact there are probably a number of buried structures within this waterlogged ground which might become apparent as parchmark features during a period of prolonged dry weather. A linear depression partially filled with water close to the northern cistern (009) may indicate the course of a culvert bringing water to the north end of the steeping pits.

The most unusual and possibly unique feature within the confines of the Saltwick Nab quarry is an inlet cut at an angle into the cliff-face midway along its east side (010). The inlet has sides cut vertically to a minimum depth of 3.2 metres. It is 17 metres in length, 6.5 metres wide and could easily be mistaken to be a natural feature caused by erosion (Figure 4A). However, its south-west corner contains important man made

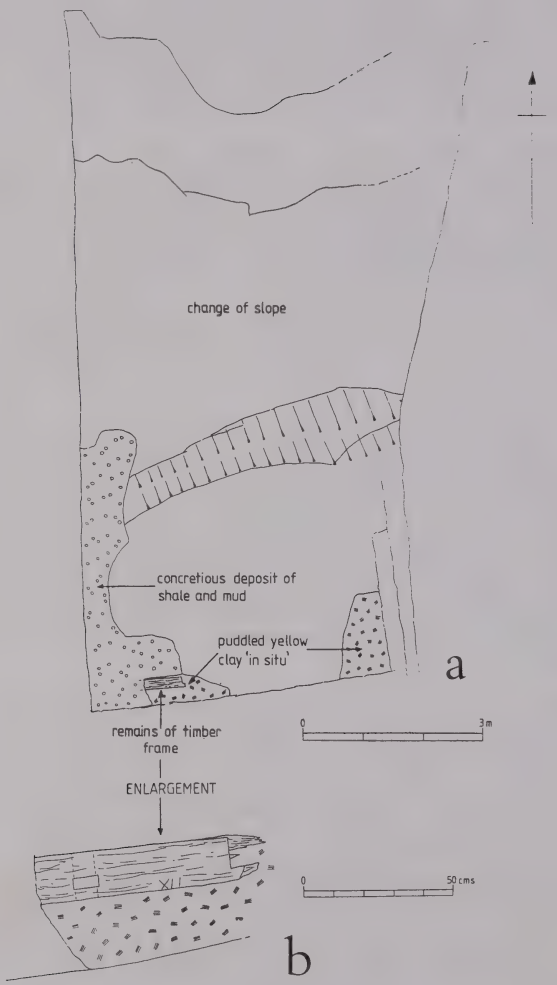

FIGURE 4A/B Plan of the liquor pit and timber frame on the east edge of Saltwick Nab quarry

evidence in the form of a substantial timber 0.75 metres in length, 14.7 cms wide and 11.0 cms thick, laid onto the grey shale floor of the cut (Figure 4B). The timber holds back a thick deposit of yellow puddled clay which has been rammed into the corner of the cut behind the timber. Waves entering into the inlet have removed any further trace of clay or timber, although faint traces of clay can be detected in the opposing south-east corner.

The upper surface of the timber carries a narrow slot through part of its thickness and there is evidence of a similar slot in the exposed end of the timber where it has broken away. Adjacent to the former slot is an inscribed carpenter's mark and these two pieces of evidence - the slots and the inscribed mark - suggest that the timber is the base of what was once a large timber frame installed within the cut. The clay would have been packed behind the frame to make it watertight, possibly held in place by planked timber sides attached to the inner side of the frame. Daniel Colwall, writing in 1678, describes the use of similar timber frames rammed with puddled clay serving as steeping pits[10]. The Saltwick example is too large and too deep to have served as a steeping pit, but its location between the previously described steeping pits and the quarry edge suggests its use as a vessel for storing raw alum liquor destined for the alum house. The question is though, which alum house - the house in Saltwick Bay which was erected about 1770, or alternatively the earlier house at South Shields where cheap coal for the evaporating process was available? If it was the former then a liquor trough would almost certainly have run along the cliff-face over a length of about 300 metres towards the beach level alum house. If it was the latter destination the close proximity of the pit to the point at which the contents could be loaded into a waiting ship bound for South Shields would make sense. Perhaps the vaulted structure at the base of the quarry on Gibson's view is associated with this pit. Evidence for the pattern of berthing within the bay is considered in the third section of this report.

Whatever the answer, it is clear that as a consequence of erosion much important evidence has been lost. Much is also currently being exposed and destroyed. For example, on the north-east tip of the quarry a number of timbers project from the eroded face (011). Much of this face is made up of waste shale dumped over the underlying grey alum shale. Close to the north-east corner of the steeping pits there are narrow lengths of timber plank projecting from a mixed dump of grey and red shale (012). The interval between the centres of these timbers (0.76-0.77 metres) is consistent and they lie parallel to one another, as if forming a flight of crude steps formerly ascending from the rocks below. The second group of timbers (011) lie in a more haphazard arrangement, but at a similar height in the cliff-face and within a similar dump of mixed shale. Close to these timbers, but further into the quarry, are two short lengths of masonry projecting through the grey shale, each approximately 2 metres in length and with a gap of 2.8

metres between their inner edges (013). Without further investigation by excavation this feature is difficult to identify, but it could be the remains of a workshop or a small storehouse.

The remains of what is certainly a building can be found at the south end of the quarry where a rectangular arrangement of shallow earthworks and stone footings defines a building divided into two rooms with a total length of 11 metres and a width of 5.3 metres (006). The 1913 Ordnance Survey 25 inch scale map identifies this rather bleak section of the quarry landscape as a 'Tea Ground' and implies that the building served as a rather remote and inhospitable cafe. The building may however, be a legacy from the period of quarrying for alum, having perhaps served originally as an office/smithy/laboratory complex similar to that excavated by the Cleveland Industrial Archaeology Society in the Boulby complex[11].

BLACK NAB QUARRY

This feature forms the eastern margin of Saltwick Bay and is separated from the site of the alum house within the bay by a distance of about 500 metres. Black Nab (014) is the smaller of the two quarries and probably the more recent excavation, developed during the second half of the 18th century. It has been cut back in a southerly direction to form a face about 220 metres in length and 30 metres in depth (Figure 5).

Subsequent collapse of overburden has concealed the lower section of the face, and has also covered much of the quarry floor. Much of the remaining floor surface is waterlogged, suggesting the likelihood of buried steeping pits below the surface turf cover, although their outline is not immediately obvious.

The only obvious feature associated with the production of alum liquor in this quarry is a 5.4 metre length of timber launder surviving close to the seaward (east) edge of the quarry (015). The launder is laid into a shallow 0.4 metre wide cut in the grey shale floor of the quarry. The sides of this cut are lined with upright timber planks, lined behind with puddled yellow clay to make the launder watertight (Figure 6). The base is also lined with clay but there is no evidence of a timber floor to the launder, perhaps because it has rotted. From the top edge of the timber to the upper surface of the clay the depth of the launder can be estimated as about 14 cms. The width between the inner edges of the timber can be measured as 25 cms. The south-east end of the launder is still covered by two flattish pieces of sandstone, evidently a remnant of the original covering.

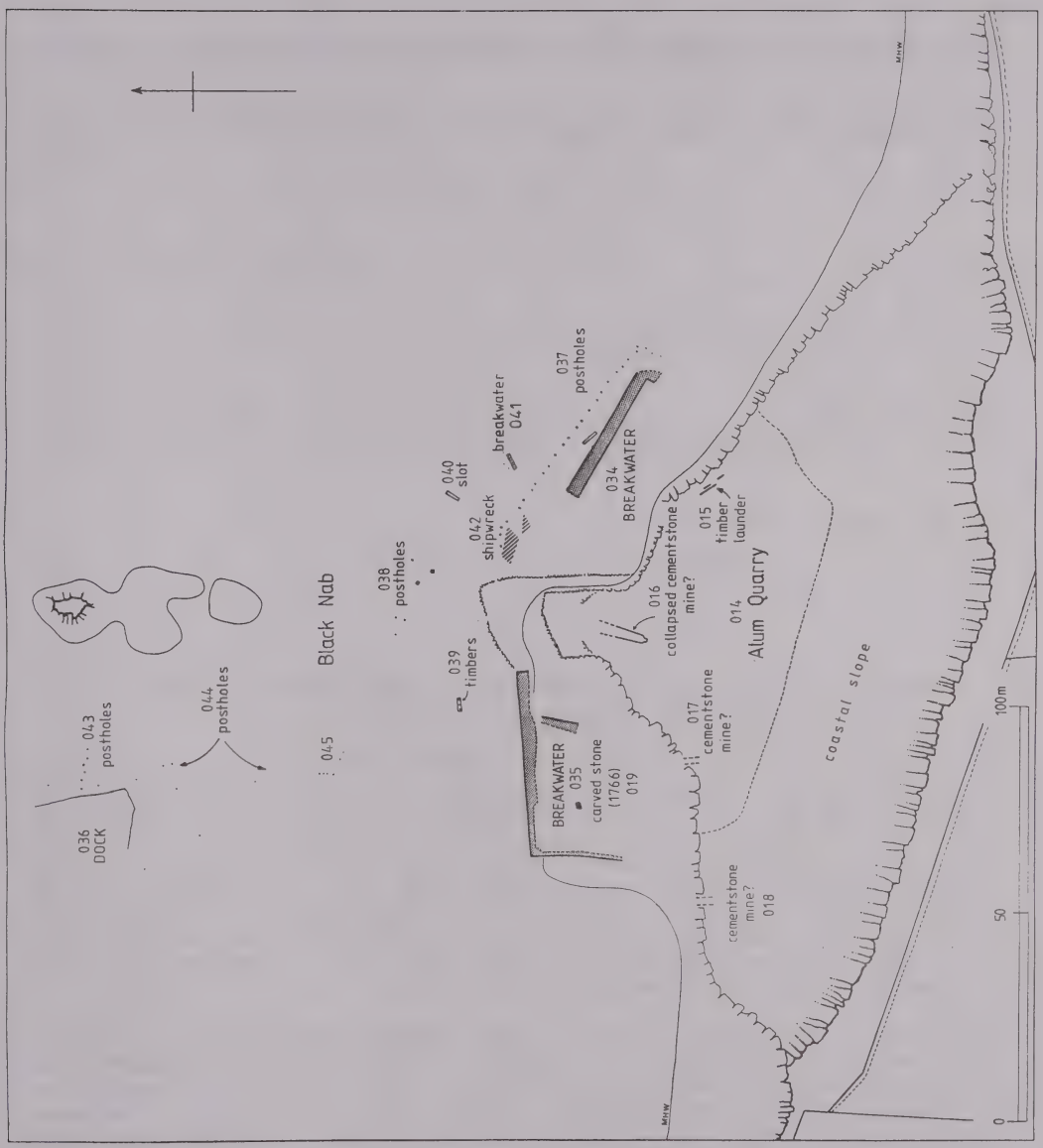

FIGURE 5 *Plan of Black Nab showing the quarry, breakwater and outer dock*

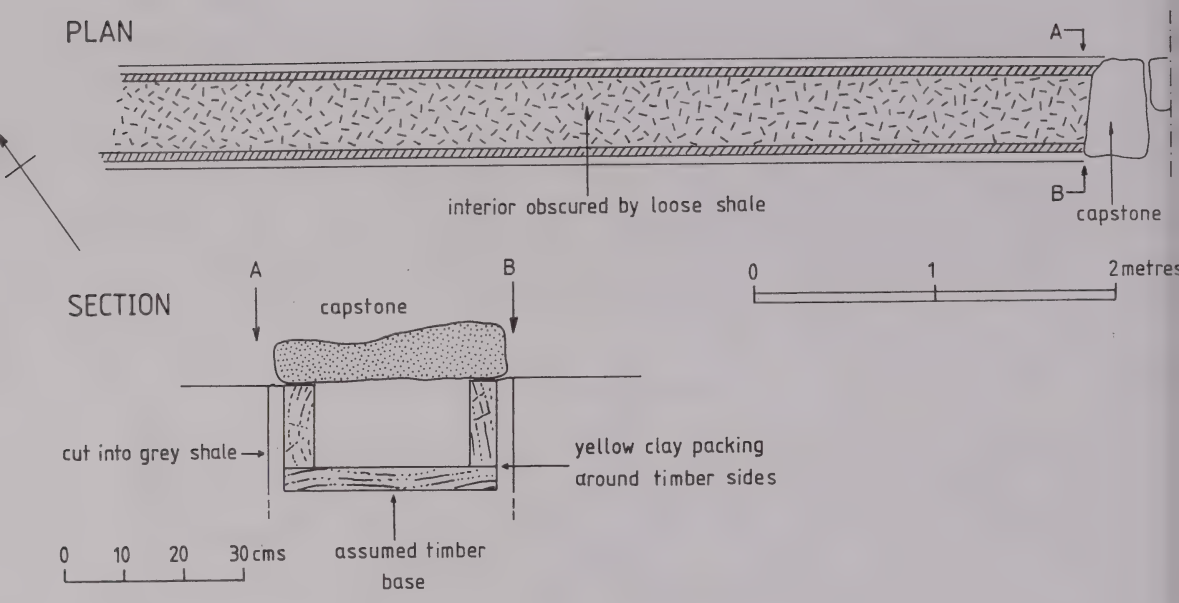

FIGURE 6 ***Plan and section across the timber launder in Black Nab quarry***

Its location close to the cliff edge suggests that the launder has served as a liquor trough, carrying alum liquor from the outer edge of the concealed steeping pits. The direction of flow is from south-east to north-west, possibly towards the alum house within the bay, or alternatively to a circular raw liquor cistern within the quarry where the raw liquor would be stored and blended to a suitable specific gravity before being conveyed to the alum house. Any evidence for the continuation of the launder along the cliff-face has disappeared as a consequence of the erosion of the cliffs.

At some stage the floor of the Black Nab quarry has been disturbed by shallow drift mining. These drifts lie above the level of the jet shale so it is not clear as to what was being extracted from them. Dogger cementstone seems unlikely because this lies within the upper horizons of the alum shale. There are three drifts, one of which has collapsed (016), leaving the other two (017 and 018) more or less entire within the face of the cliff below the quarry, although inaccessible without the use of a rope. The 1854 1:10560 scale Ordnance Survey map shows a long flight of steps passing across the front of the two

drifts, evidently providing a means of access to and from the beach. It is probably safe to assume that these drifts were in use when this map was published. The collapsed drift is defined now by a shallow gully which extends back about 12 metres from the furthest edge of the quarry. Within this gully it is possible to trace two narrow lengths of timber extending horizontally across the width of the gully, possibly serving originally as crude bracing within the drift.

The commencement of quarrying on Black Nab is probably closely associated with the date of '1766' which is carved into a massive block of ironstone below the edge of the quarry (019). The stone in question originally formed part of a breakwater erected around the north and west edge of the north-west corner of the quarry, but it has subsequently been pushed off the breakwater towards the quarry edge. This block is 1.46 metres in length and a metre wide (Figure 7) and carries the date in figures 31 cms high. It also carries the initials I+S+ (I=J?). It is probably more than a mere coincidence that this date for the breakwater, and perhaps for the commencement of quarrying, corresponds closely with the date of circa 1770 given by George Young for the construction of the alum house. Taken together these two pieces of evidence imply a major change in the layout and mode of operation of the Saltwick site.

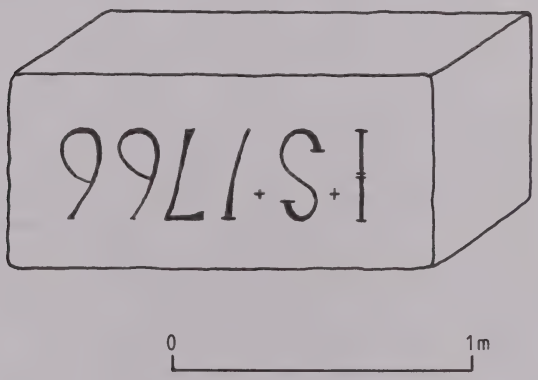

FIGURE 7
Detail of the dated stone from Black Nab breakwater

EVIDENCE OF SECONDARY PROCESSING - THE ALUM HOUSE

Between the two nabs and within Saltwick Bay itself (Figure 2) lie the structural remains of what is almost certainly the Saltwick alum house where raw liquor from the two quarries was evaporated to produce the alum crystal. Though perhaps geograpically separated as a distinct entity, the alum house formed the hub of any site producing alum. It was here that the 'housemen' practised their inherited skills, using rule of thumb methods to convert the raw liquor into the refined translucent alum crystal. Refining the alum crustal was a complex process which involved boiling the liquor to concentrate its strength and to deposit unwanted impurities. It was then blended with an alkali - either potash or human urine - at which point crude crystals would form These had to be purified in a process called 'roaching' which involved dissolving the crystals in steam and recrystallising in timber roaching casks.

The alum house usually constituted a range of long stone and pantile sheds arranged on different levels so that where possible liquor flowed by gravity. The arrangement was usually complemented by workshops, including a smithy, plumbers' shop and joiners' shop, plus storehouses, boiler houses, a laboratory and perhaps accommodation for the workforce. An arrangement such as this would develop gradually as innovations were introduced and output was expanded, unless of course the alum house was built from scratch, as happened at Kettleness after the original alum house slipped into the sea in 1829.[12]

Before the raw quarry liquor was converted to the crystal it first had to reach the alum house, probably via a timber or stone liquor trough laid close to the seaward edge of the cliffs. Unfortunately any evidence for such a feature has been lost due to erosion, except perhaps for the short length of timber launder within Black Nab quarry (015). The loss due to erosion is emphasised by the fact that Gibson's view shows a road descending from the hollow in the centre of the cliffs and passing along the cliff face towards Saltwick Nab quarry. All trace of this roadway has now disappeared. Alternatively the liquor may have been physically carried in casks, either by boat or by horse drawn carts, but this possibility seems unlikely because the fundamental principle underlying the arrangement of any alum site was to make use of gravity wherever possible for the conveyance of liquor.

It is still possible to trace the back wall of a circular stone cistern (020) incorporated into the base of the shale cliffs between Saltwick Nab quarry and the alum house (Figure 8). This vessel has almost certainly served as an intermediate storage vessel for alum liquor passing down from the quarry. The flagstone floor of this vessel with its underlying clay base is perched about 3.5 metres above the present level of the beach, and it would therefore seem highly unlikely that any alum liquor was actually physically hauled up to this vessel.

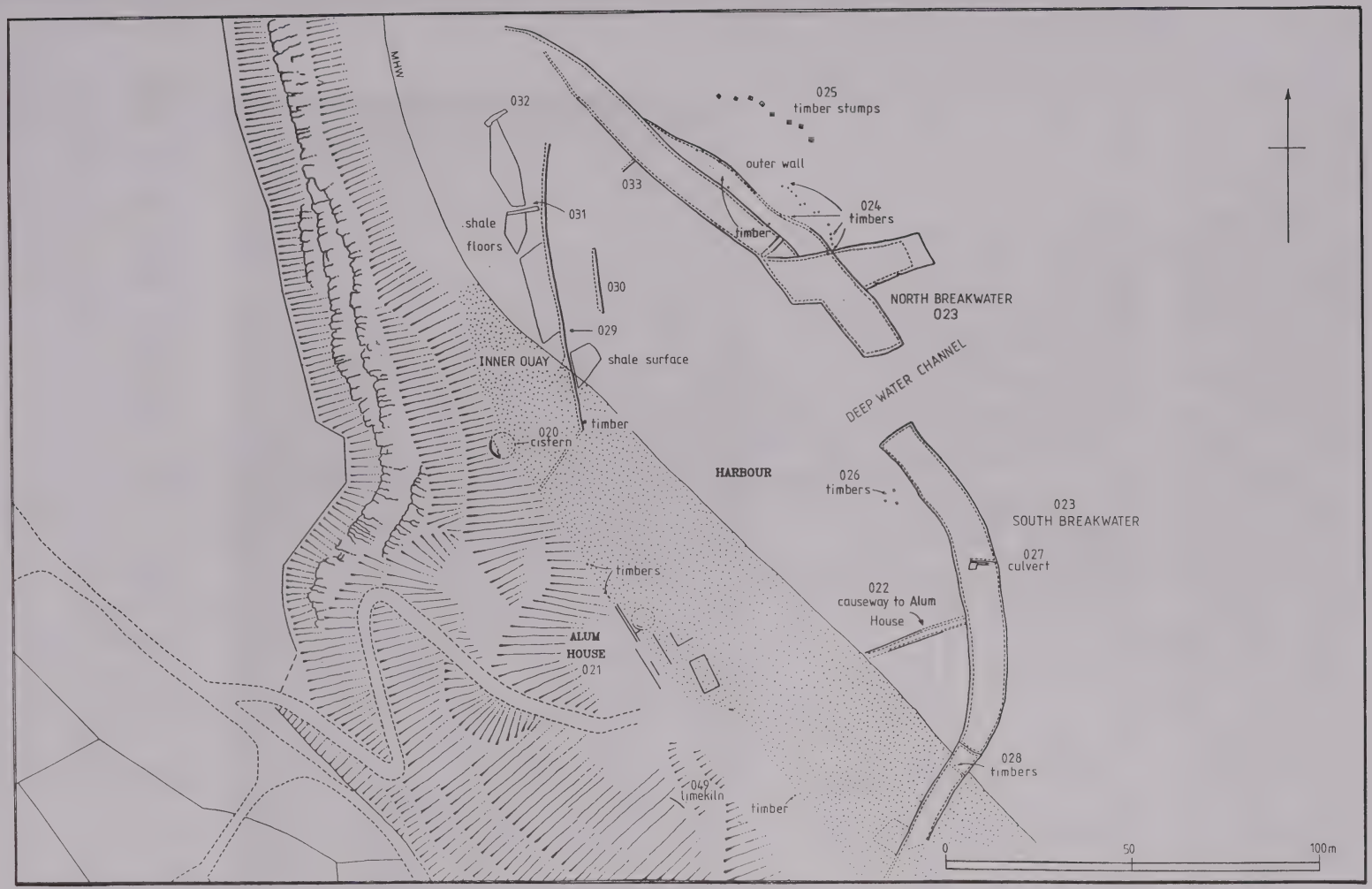

FIGURE 8

Plan of the breakwater around the Saltwick Bay alum house

Incidentally the collapse of the front edge of this cistern as a consequence of cliff erosion has provided the archaeologist with the opportunity to see quite clearly in section the construction of a watertight liquor-holding cistern. The vessel is built into a cut in the grey alum shale, the sides of which have been packed with yellow clay and then lined with a single skin of curved sandstone blocks to form an internal diameter of about 7 metres.

The remains of the alum house (021), which formed the subject of weekend excavation work over a period of some 18 months, lie about 60 metres to the south-east of this vessel at a point where the boulder clay cliffs meet with the highest section of the sandy beach. (The distinct reddish colour of this sand should be noted, since it contains a high proportion of calcined alum shale). The lowest point of the boulder clay is held in place by a battered masonry retaining wall 26 metres in length which separates the surviving stonework lying under the sand from the boulder clay between letters A and B on Figure 10. During the course of the excavation it was found that this purplish brown clay both underlies and overlies the stonework, possibly because in the latter case the clay has slumped over the remains. The top surface of the clay behind the wall was not investigated by the excavation but it appears to incorporate stone footings and yellow clay, the latter suggesting a puddled lining for an unknown vessel.

PLATE 3 *Looking north-west across the upper and middle levels of the alum house. The retaining wall is on the left. The scales (2 metres length) are placed on the clay/sand terrace*

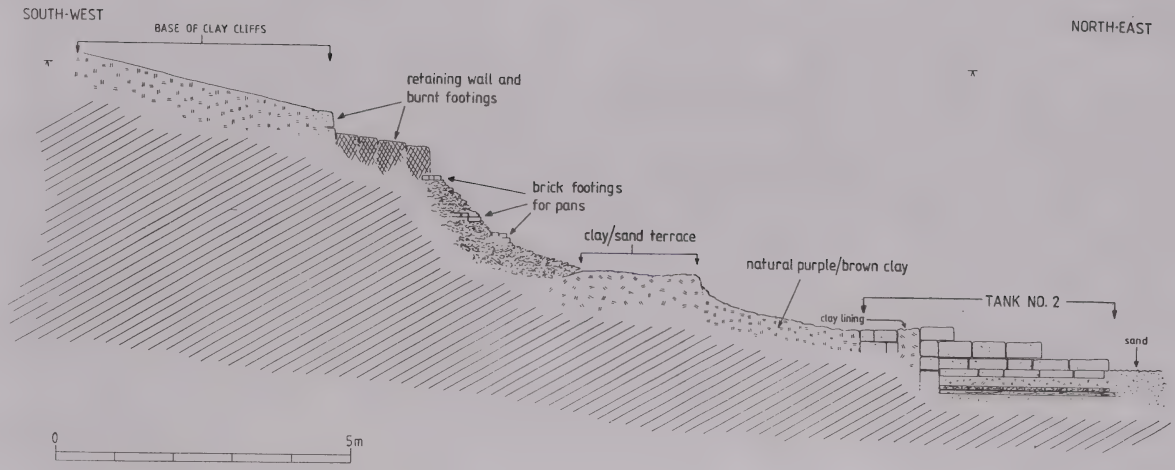

FIGURE 9

Profile looking north west across the excavated alum house

The stonework beneath the sand lies 1.5 metres below the surviving top surface of the retaining wall (Figure 9). This change of level is not consistent across the site because there are several gradual descents involved, and these subtle changes are an integral part of the whole arrangement of the alum house so that successive stages of production took place through a descent in level. For convenience the remains can be divided into three terraces; the upper terrace above the retaining wall; a middle terrace comprising a bed of decayed grey and yellow clay at the foot of the wall, and below this the lower terrace comprising the two stone tanks, plus intervening stone footings (Plate 3). To the north-west of the two tanks there is a third circular stone tank surviving to a depth of about 1.5 metres with its flagstone floor sunk below that of the two rectangular tanks. Each of these features is described in succession in the following account.

Erosion continues to destroy both the stone footings and the masonry retaining wall. In the case of the stone footings the depth of sand cover determines the rate at which they are being eroded. Winter storm tides continue to strip away the sand cover and then tear at the masonry. Any mortar used during their construction has long since disappeared. Erosion is also stripping away the stonework of the masonry retaining wall and since this was first recorded by rectified photography in 1991 perhaps as much as one quarter of the entire elevation has disappeared. All features uncovered by excavation, including the retaining wall, were planned at a scale of 1:20. The composite plan (Figure 10) is the result of scaling these drawings down to 1:50 scale. However, it was first necessary to uncover much of the structural evidence beneath the sand and before this was done a resistivity survey was undertaken over a grid 50 metres in length (from north-west to south-east) and 15 metres in width (from north-east to south-west). This gave some indication of the position of high resistance features extending to a distance of about 15 metres from the face of the retaining wall towards the sea. The purpose of the initial excavation was to outline and identify individual features and this was partly achieved by cutting three trial trenches, each 1.5 metres wide. These trial trenches confirmed that evidence survived to a distance of up to 15 metres from the wall, over a length of about 25-30 metres corresponding roughly with the length of the retaining wall. Subsequent excavations involved removing the sand from this entire area, not all in one go, but rather as a series of small excavations each covering about 25 square metres. The depth of sand cover over the footings varied greatly but could be as much as one metre in depth, increasing as digging progressed in a seaward direction. This had to be done during the interval between high tides and preferably without the presence of either wind or children to collapse unstable sections!

In the following account the evidence uncovered by the excavation is considered as a series of components which collectively make up the remains of the alum house.

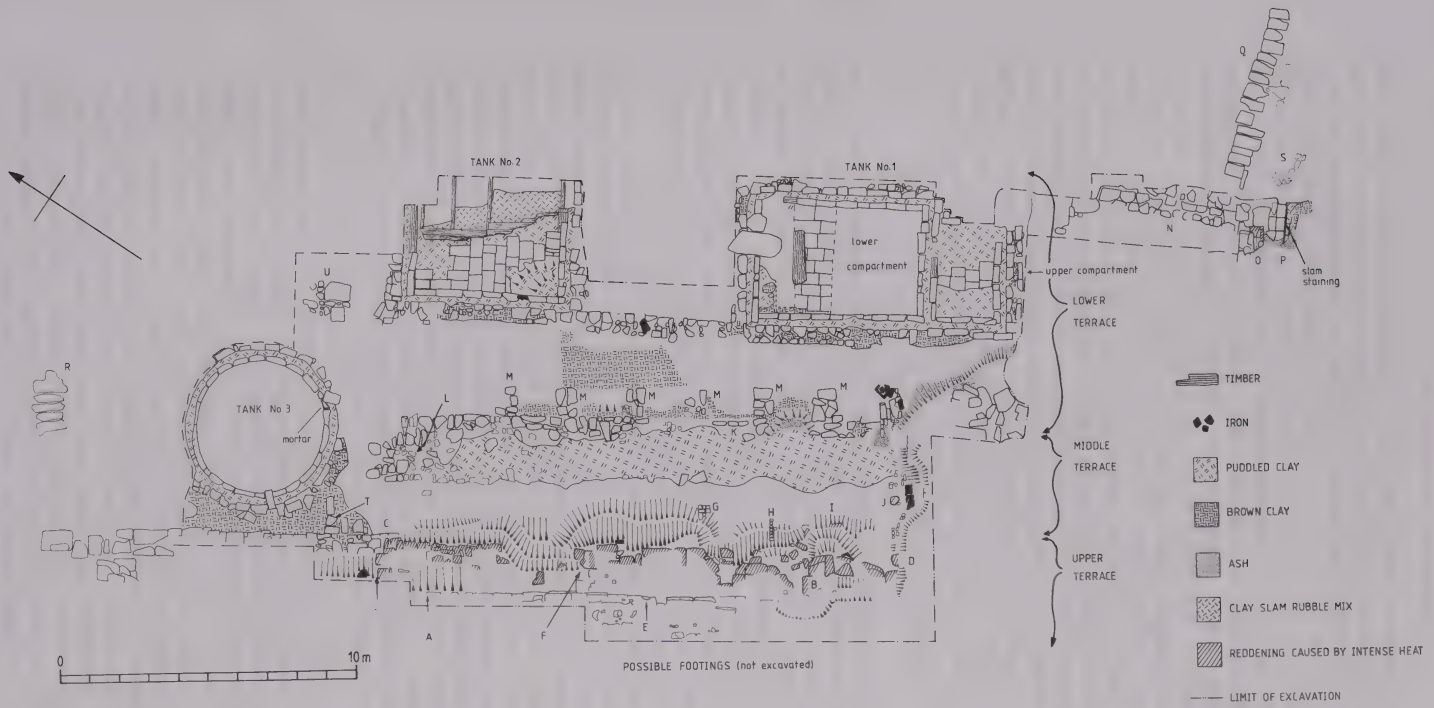

FIGURE 10

Plan of the excavated alum house in Saltwick Bay

Unfortunately firm evidence for dating its construction was not recovered but it can be assumed that this was the house erected according to George Young in about 1770. Subsequent minor alterations to the structure are suggested by flush joints along the length of the retaining wall, but otherwise the evidence seems to belong to a single phase of construction. In this respect the Saltwick alum house differs from a more typical site such as the Ravenscar alum house where the buildings have been added in phases, thus exhibiting an organic growth over a period of about 200 years.

It should be noted that for the convenience of the following description the alignment of the main axis of the excavation is assumed to be north-south, although in fact the footings are actually aligned diagonally, from north-west to south-east. The levels on Figures 9 and 10 are relative to a site datum established on the top of the north end of a breeze block wall slightly west of the upper level of the alum house.

THE RETAINING WALL

This feature actually comprises two adjoining walls, but for the purpose of this report they are described together. The back skin (or west skin, between points A-B on Figure 10) serves as the retaining wall against the lowest point of the boulder clay cliffs, whereas the outer skin (or east skin, between points C-D), which is the more substantial of the two, serves as a structural support, probably for the boiling pans associated with the process of evaporation in the alum house.

The top edge of the back wall can be traced over a length of 14 metres between points A and B. It is built of large well dressed masonry blocks, evenly coursed and placed so as to form a slightly battered profile. Two courses are exposed above the top surface of the east skin of the wall. The full depth of the back face has not been exposed by excavation since this would have accelerated the rate of its erosion, but it probably extends to at least the same level as the footings forming the first terrace below the retaining wall. At point E the seaward edge of one of the stone blocks carries a semi-circular recess, perhaps indicating the position of a pipe for carrying liquor, alkali or water used in the process.

The outer section of the retaining wall is heavily eroded and therefore rather difficult to interpret, but since the masonry has been burned to a bright red colour it can be clearly distinguished by the area cross-hatched on Figure 10. This burnt section is 17.5 metres in length, although its south end at point C continues into the slumped boulder clay. Its width varies slightly but averages about 1.5 metres. The variations appear to correspond partly with the manner in which the face has been stripped by erosion, and partly with the way in which the wall is built as a short series of projecting buttresses. What is most noticeable about this burnt length is that it is made up of substantial masonry blocks, implying that something heavy has rested upon or against the wall. The distinct colour

caused by the burning, together with the presence of occasional globules of congealed molten lead, suggests that this was the site of the evaporating pans likely to have been associated with the alum house.

The top surface of the block at point F carries a slight hollow chamfer across its west edge. The purpose of this feature remains uncertain.

Beyond point D the nature of the outer skin of the retaining wall changes. The width decreases markedly to a less substantial double thickness structure with a rubble core and occasional through blocks tying the two skins together. The back edge retains a substantial section comprising layers of small coal, burnt shale and clay. Much of this section was exposed when a major portion of the wall was stripped away by the sea during winter gales in 1992. The presence of the small coal and burnt shale within the section probably suggests that an enormous amount of dumping took place behind the retaining wall after its erection.

For the evaporating process taking place against the burnt length marked C-D large rectangular open-topped lead pans were used. Measurements from contemporary written sources suggest dimensions for the pans of 10 feet (3.05 metres) in length, 5 feet (1.52 metres) in width, and a depth of 2 feet (0.6 metres) increasing to 2½ feet (0.76 metres) at the front to allow for drainage of the pan[13]. These were placed on 2 inch thick cast iron plates raised on firebrick walls (Figure 11). By applying heat generated from burning small coal to the underside of the plates it was possible to boil the raw liquor and concentrate it by evaporation so that a strong solution was produced. (This may account for the presence of so much coal in the section behind the retaining wall). Several pieces of iron plate still remain in-situ within the fabric of the outer section of the retaining wall, but perhaps what is more important, brick footings can be traced at points G, H and I. Those at points G and H are several courses in depth and probably represent part of the corresponding supporting walls beneath a single pan.

At point J there is an extensive arrangement of in-situ brick projecting from beneath the slumped boulder clay and extending to a minimum depth of 8 courses (0.7 metres). Again these bricks are likely to be part of a support wall for an evaporating pan, especially as there is iron plate mixed amongst the courses. The line of bricks immediately behind the largest concentration of plate has been heated to a point where it has become vitrified.

The area of hachuring against the reddened section of the wall represents a thick accumulation of bright red sand, decayed brick and burnt red shale. It also overlies some of the brick footings for the evaporating pans where they survive in-situ. It is difficult to determine whether the deposit is contemporary with the evaporating pans and has perhaps accumulated beneath them, or whether it results from subsequent

deterioration of the burnt masonry and the brick footings. If the former were the case one would expect to find a large amount of ash amongst the deposit, but since it does not contain ash it is more likely to result from deterioration.

THE MIDDLE LEVEL - THE CLAY/SAND TERRACE

This feature lies immediately below the outer section (C-D) of the retaining wall and runs parallel with the wall over a length of about 15 metres. Its seaward edge is retained by a badly eroded double thickness retaining wall, of which only the footings survive - best seen at point K. The west edge of the terrace actually continues beneath the accumulation of red sand and brick described in the previous section (see Figure 9) so it is difficult to assess its full width, but it may well extend up to the base of the east skin of the retaining wall C-D. The north end of the terrace gradually merges with a second area of large rubble sandstone footings (L), burnt on their top surface to an intense red colour. Finally the south end extends up to the brick courses (J) described in the previous section, although at this point the terrace is heavily eroded and it is therefore difficult to establish any relationship between the two features.

The terrace is composed of a yellow-grey compact clay, but with a distinct gritty texture. The gritty texture suggests that the clay contains a certain amount of decayed sandstone, possibly derived from the decay of the footings at points K and L. It has a slightly undulating top surface 0.8 metres below the top surface of the outer skin of the retaining wall (see Figure 9). At several points it is stained to a darkish grey colour by the presence of small coal or coal dust.

The original purpose of the clay/sand terrace was not fully resolved from the results of the excavation. Possibilities are considered in more detail in the discussion at the end of this section, but it is worth noting that the use of puddled clay as a watertight lining has already been observed, notably at the base of the steeping pits in the Saltwick Nab quarry. The yellow clay on the middle level of the alum house may well have been put to a similar use, forming a watertight lining beneath a large tank or cistern immediately below the evaporating pans. Alternatively, the presence of so much sand in the clay might suggest that it has formed an even base for a flagstone floor surrounding the evaporating pans. The double thickness wall on its seaward edge (K) is retained by a series of short projecting buttresses for which the footings still survive (each marked with the letter (M) on Figure 10). These are in line with the brick footings described earlier (G,H,I and J) and this suggests that they are associated with the evaporating pans, perhaps forming the base of flanking walls around each pan, which would provide some protection for the housemen stoking each hearth(Figure 11).

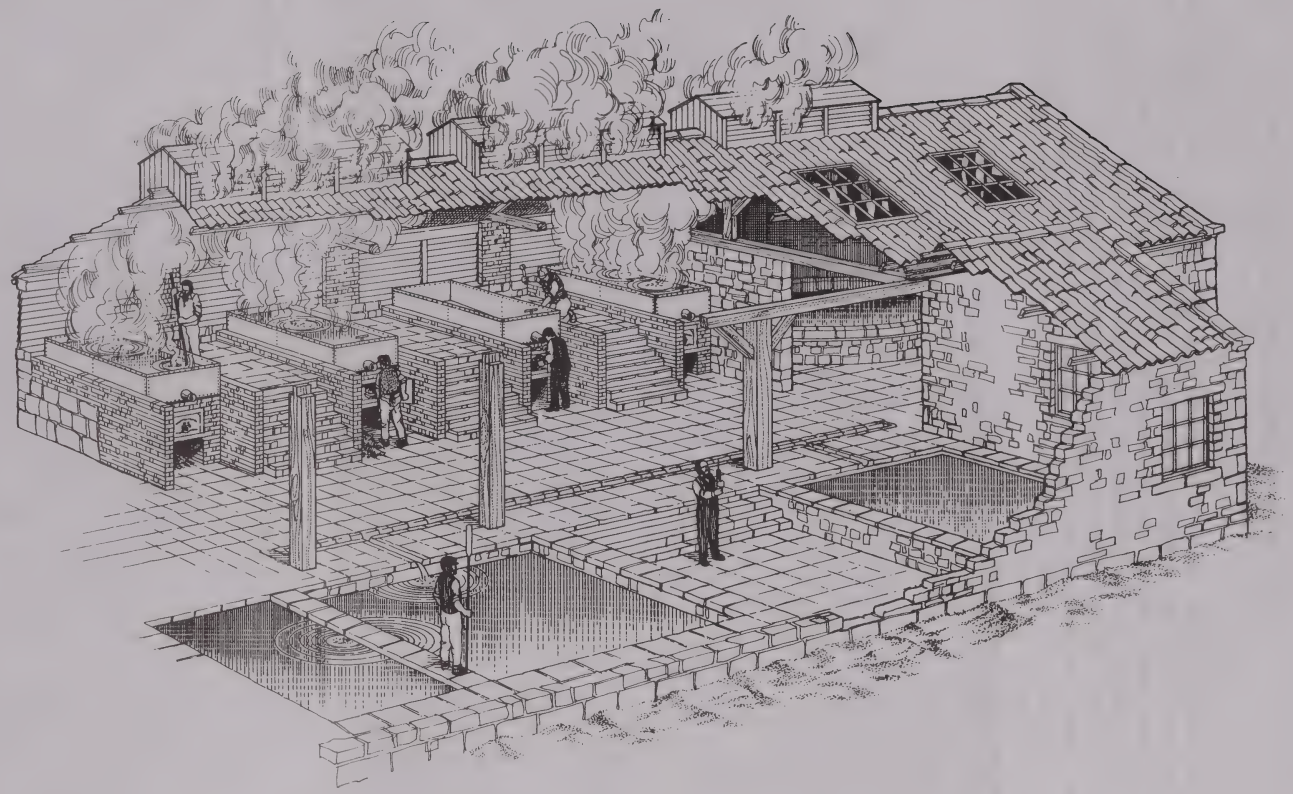

FIGURE 11

A conjectural reconstruction of the interior of the Saltwick alum house showing evaporating pans and crystallising tanks

THE LOWER LEVEL - TANKS 1 AND 2

Together with tank no.3 the remains of these two tanks form the lowest level of the excavated footings associated with the alum house. They are separated from the clay terrace and buttressed wall described previously by a narrow strip of purple-brown boulder clay, which is evidently the continuation of the clay cliffs held in place by the retaining wall. This strip appears to have been levelled, perhaps deliberately, but perhaps by the action of wave erosion.

PLATE 4 ***Excavation and recording of tank number 1 on the lower level of the alum house. The upper compartment of the tank is nearest***

Tank no.1 (Plate 4) is the larger of the two tanks and also the most complete, measuring internally 7.8 metres in length (north-south) and 3.5 metres in width (east-west). The full depth of the vessel is no longer apparent since some of the upper courses have been stripped away, but at least three courses of the interior west wall survive to suggest a minimum depth for the vessel of 0.57 metres to the flagstone floor. It differs from tank no. 2, not just in terms of its size, but also because it is divided internally into two compartments by an east-west double thickness cross wall. The interior of the cross wall is lined with puddled clay, suggesting a deliberate attempt to separate the contents of the two compartments. This conclusion is supported by the fact that the flagstone floors

of the two compartments are at different levels - the smaller south compartment has a floor level 0.64 metres above that of the larger north compartment. Both floors are laid over a thick bed of puddled yellow-grey clay which in turn is placed over a compacted bed of burnt red alum shale mixed with sand and clay. Evidence of a timber frame underlying the whole structure was found at two points - beneath the interior east wall and beneath the mid section of the cross wall between the two compartments. The significance of this frame is considered in the discussion of tank no.2.

Both tanks are similar in construction and share a common back (west) wall which continues across the space between the two tanks. The gap was assessed by the excavation but this failed to locate evidence for a middle tank and instead encountered a bed of compact red shale similar to that beneath the two tanks. This back wall is a double thickness masonry structure which appears to be bonded with a core of purple-brown clay. Similar double thickness walls also form the north, south and east edges of both tanks and these are separated from the single thickness interior walls by a thick puddled clay lining which effectively makes the vessel watertight.

There is less of tank no.2 surviving but because its east wall has been removed by erosion the excavation was able to record a perfect section across the construction of the tank. This vessel is shorter than tank no.1 measuring 4.8 metres in length internally, but the width probably corresponds with that of tank no. 1, suggesting a vessel with a square outline. Again the original depth is uncertain since only two courses survive above the level of the flagstone floor in the south-west corner of the tank.

The sequence of construction is illustrated by Figure 12 and Plate 5. It begins with a layer of compacted clay, sand and burnt shale, which in turn appears to be laid over a compacted mix of sand and rounded burnt shale pieces. The clay/ shale layer supports a timber frame constructed of widely spaced pitch pine joists which in turn support a series of transverse planks laid across the upper surface of the joists. The ends of the planks abut the double thickness side walls and the latter are almost certainly laid on similar planks, otherwise they would soon subside into the soft underlying sand/shale mix. The purpose of the main timber frame seems to be to give a rigid structure to the tank, otherwise the masonry walls would subside and break open under the weight of the contents in the tank. What is not clear is how the horizontal thrust of the contents against the side walls would be restrained. They may have been clasped by iron bands encircling the exterior of the tank, or alternatively the ground level may have been raised up around the sides of the tanks after they were constructed.

The interior single skin walls certainly rest on timber planks laid across the width of the tank, although in this case the planks effectively allow the interior walls to float on the clay lining of the tank. This clay lining is 16-18cms thick and

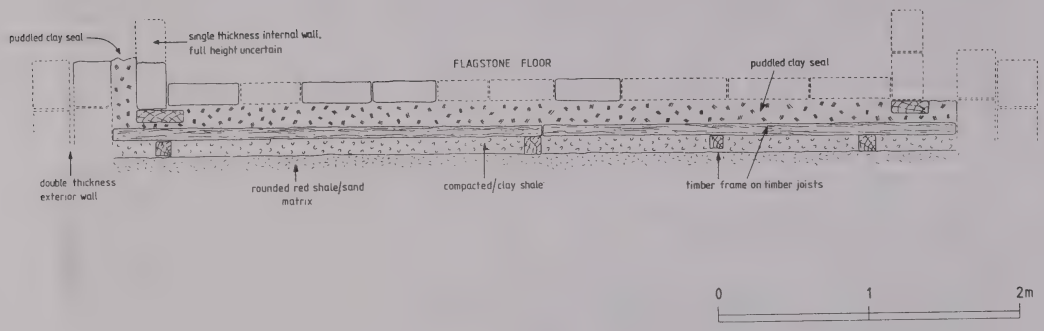

FIGURE 12 *Section looking west across tank no 2, illustrating its method of construction*

PLATE 5 *Section (looking south-west) across the construction of tank number 2 of the alum house. Note the timber frame and clay lining below the flagstones. (Scale 1 metre length)*

is continued into the gap separating the side walls. Its purpose is obviously to make the tank watertight. Finally the floor of the tank is formed of thick sandstone slabs laid end-to-end, flat on the clay, and abutting the interior masonry walls.

Levels taken across the floor of the lower compartment of tank No 1 suggest that there is a deliberate slope to the floor with a descent of about 7 cms down from west to east. This may be due to subsidence or it may be deliberate, assisting the drainage of the tank when the contents were run off.

The technique of using a rigid frame to support the weight of liquor in the tank illustrates an interesting response to the problem of building in such a marginal environment. However, the benefits of having the alum house as close as possible to the point at which raw materials were introduced must have outweighed the drawbacks. The technique of using timber frames beneath the tanks is not unique to Saltwick, since a similar joist and plank structure can be found projecting through the rocks at the base of the cliffs below the Loftus alum quarry (grid ref. NZ 734202). Next to this structure at Loftus are the remains of a circular stone cistern with part of its perimeter wall and flagstone floor still intact, probably serving as a vessel for the storage of raw liquor in a similar manner to tank no.3 on the edge of the Saltwick alum house. The two Loftus structures project at a slightly acute angle from the rocks, suggesting that they have fallen with a landslip and therefore may not have been built directly onto the rocks at high-water mark.

The possibility of a third rectangular tank is suggested by the presence of footings (N) uncovered slightly south of tank no.1. These can be traced from a point close to the south-east corner of tank no.1 over a length of about 5 metres. Though badly eroded the footings appear to be the base of a double thickness wall, bonded with a core of purple-brown clay. They may alternatively be the footings for the east wall of a building added to the south end of the site which has otherwise now disappeared. Any further investigation of these footings in a westerly direction was prevented by a thick wall of purple-brown boulder clay which has evidently slumped forward from the base of the cliffs. The south end however terminates against the face of a substantial double thickness retaining wall (O) built of irregular sandstone blocks with a rubblestone core. This retaining wall survives to a height of three or four courses over a base of large sandstone blocks. The south face has been partially burnt to a bright red colour. The full length of this wall was not determined by excavation since it disappears beneath the slumped boulder clay but its continuation suggests that a large portion of the south-west corner of the alum house lies concealed beneath this slump. It is therefore perhaps slightly ironic that further erosion of the base of the cliff is required before the extent of this concealed evidence can be determined and recorded.

Clearly this emphasises the importance of continued monitoring of vulnerable coastal archaeological sites such as Saltwick.

At this point it is perhaps appropriate to describe two further structures on the extreme south-east corner of level three which were uncovered by the excavation. The first of these is a stone culvert (P) running parallel with and immediately behind the retaining wall described in the previous paragraph. It has a floor of three evenly cut flagstones laid on a bed of yellow clay and sides formed of single thickness masonry walls. As can be seen from Figure 10 the north wall of the culvert actually abuts the back of the retaining wall. The south wall is partially stained to a bright yellow colour, and this suggests the former presence of an alum liquor within the culvert containing iron silicate or iron oxide impurities. The original direction of flow was probably from west to east, but because the surviving section of the culvert disappears into the slumped clay it is uncertain where it is coming from. The yellow staining could suggest a residual waste liquor from the production of the alum crystal containing a high amount of iron silicate impurity which needed to be discarded onto the beach. However, this seems unlikely because such waste - known as 'slam' - was normally discarded as a solid crust.

The second feature, this time uncovered not by excavation but by a winter tide removing the sand cover, is a 6 metre length of sandstone wall (Q) comprising large blocks of rectangular stone laid side by side. This appears to be the remnant of a double thickness wall providing protection around part of the alum house, but also doubling up as a narrow causeway linking the south-east corner of the house with the massive breakwater forming the perimeter of the enclosed harbour. Several blocks survive on the south face of the causeway to suggest that it had a width of between 1.35 and 1.4 metres. Much of the seaward end of this causeway (022) adjoining the breakwater still survives in situ and is regularly exposed when the tide removes the sand cover from within the sheltered area formed by the breakwater (Figure 8). Its prime function seems to have been to serve as a causeway for use when the tide had entered into the enclosed area formed by the breakwater. It should be noted that a similar length of large blocks (R), laid side-by-side, is occasionally revealed at the north end of the alum house. This has probably served a similar function i.e. acting as protection and as a causeway to the breakwater. However, it is not so well preserved as the former structure.

There are more footings (S) in-situ slightly to the south and immediately opposite the end of the previously described culvert but the full extent of these footings has yet to be determined by excavation.

TANK NUMBER 3

This tank (Plate 6) lies on the north-west corner of the excavation, immediately below the north section of the retaining wall, before point R. It obviously differs from the

PLATE 6
Part of the perimeter of the circular cistern of the alum house during excavation.
Note the clay lining between the inner and outer skins.
Scales 2 and 1 metre

tanks numbered 1 and 2 because of its circular outline. This seems to imply a different function from the latter two vessels. The tank has an internal diameter of 4.2 metres and is also much deeper than the straight-sided tanks. The back section of the interior wall survives to a height of seven masonry courses above the flagstone floor, which gives a minimum depth of 1.5 metres to the vessel.

The method of construction is similar to that of tanks 1 and 2. It is clear that the vessel has been incorporated into a cut in the purple-brown boulder clay at the foot of the cliffs. The interior wall is single thickness only, and in this case the individual blocks are cut with a slightly concave inner face. Timber wedges rammed between each block ensure that the circumference of the wall maintains a tight curvature which is not distorted by the weight of the liquid contents within the vessel. Mortar was probably not used for bedding the individual blocks because the acidity of the alum liquor would quickly attack the lime content of the mortar. Additional strength to the construction of the vessel is also given by the inclusion

of occasional through stones between the interior and exterior walls of the vessel. The exterior wall is a double thickness structure with an interior core of rubblestone. Purple-brown clay has been used for bonding this core, rather than mortar. The gap between the two walls is filled with rammed puddled yellow clay. The interior of the vessel could not be fully cleared due to the presence of large, sea-deposited boulders. It was however possible to excavate a 0.6 metre wide trench across the interior diameter. Beneath the sand the excavation encountered a layer of purple-brown clay up to 1.2 metres in depth containing broken brick and clay pantile. Below the clay a thick bed of silty grey mud covered the flagstone floor to depth of 0.35 metres. The lower section of this mud seemed to be composed of decayed plant material and a sample was therefore taken for analysis by the Environmental Archaeology Unit attached to the University of York. The results of the analysis suggest that the mud is a deposit composed of silts derived from water standing within the tank (Appendix A) probably after the alum house had ceased to operate, although one cannot rule out the possibility that water originally stood in the tank when alum was being produced. The plant material within the silt was identified as being mostly pieces of pine branch and needle. The source of this material does not immediately suggest itself because one would have to go down into the more sheltered valleys of the Esk and its tributary streams to find such growth.

The trial trench 0.6 metres wide cut across the diameter of the vessel confirmed the existence of a flagstone floor. Unfortunately it was not possible to record these stones due to the continuous presence of a grey slime oozing from the section. It was however possible to take levels across the floor and these reveal a very gentle slope towards the eastern side of the vessel i.e. in the same direction as the slope recorded across the floor of tank number 1.

The contents of the tank are further considered in the following discussion section. It is worth pondering though as to why it has a circular outline. Because of its depth tank no. 3 would hold a greater volume of liquor compared to tanks 1 and 2, and this was counteracted by setting most of the vessel into an excavation in the natural boulder clay. The absence of any continuous vertical joint in the interior wall would increase its strength and the ability of the vessel to counteract sideways thrust would be enhanced by the overall weight of the two walls. From a practical point of view it would be easier to agitate the contents of a circular vessel. It would also be easier to clear the floor of accumulated solid impurities without damaging the stone sides of the vessel.

Finally, before going on to discuss this evidence there are one or two structures around tank no.3 worth highlighting, although their state of preservation is very fragmentary. Between the exterior wall of the tank no.3 and the retaining wall there are footings of a double thickness masonry structure set (T) into the brown clay. They abut the seaward face of the retaining

wall and this might suggest that they have served originally as the base of a flight of steps linking the upper level of the alum house with level two. Another possibility is that these footings are the base of a wall carrying one of the roof trusses across the north end of the building housing the evaporating pans as shown on Figure 11. However, because the evidence is so fragmented it is difficult to confirm this suggestion. They may be nothing more than the base of a buttress against the face of the retaining wall.

A second area of fragmented footings (U) lies on the opposite, seaward side of the tank, close to the north-east corner of tank no.2. The footings may be the northerly continuation of the range of tanks on the lowest level, although again they are too fragmented to suggest any firm conclusions about their original form. However, it is noticeable that they incorporate several large slabs of stone, which, because of their size, would provide greater stability to any structure erected upon them. Unfortunately these footings lie on the edge of the excavated area at the point where the sand cover becomes too deep to be removed by hand shovelling and trowelling.

DISCUSSION

The excavation has recovered sufficient evidence to confirm, with some degree of certainty, that this is the site of the Saltwick alum house. The remains are admittedly fragmented, but they show characteristic evidence of burning suggesting the site of the evaporating pans, whilst the discovery of clay-lined tanks on the lowest level provides evidence for the subsequent settling and cooling of the concentrated alum liquor. One would expect this evidence to be arranged in descending order so that advantage could be taken of the potential for transferring liquids by gravity, and indeed this appears to be the case.

What is not clear from the evidence is the extent to which the alum was processed. Was it merely concentrated on this site before being containerised and shipped to South Shields (Watson's description implies that vessels were specially adapted for the purpose), or was it concentrated, combined with alkali and cooled to produce the pure alum crystal required by the dyeing industry? Comparison of the evidence with that from other sites, notably the Peak alum works, suggests that a greater range of structures would be required to facilitate the entire process and produce the alum crystal. Evidence for the final stage of crystallisation in timber casks within a 'Tun House' is absent, as is any evidence for subsequent washing, drying, grinding and storage of the crystals. It must though be remembered that the site has suffered nearly 200 years of erosion and this may well have stripped away any easterly seaward continuation of the alum house situated beyond the two rectangular tanks.

Despite the fragmentary condition of the remains it is possible to draw some firm conclusions from the evidence and from these conclusions suggest an interpretation of the function of the various structures. The reconstruction drawing (Figure 11) stems from this interpretation but it should be stressed that much of the detail is based on conjecture rather than firm evidence. Stages in the process subsequent to evaporation are not illustrated clearly by the archaeological evidence and there is particular confusion over the identity of the clay/sand terrace. Several possibilities are therefore considered in the following discussion.

The arrangement of the various structures over several different levels has already been noted. Raw liquor arriving from the quarries would normally be held in a circular cistern above the evaporating pans. However, if one excludes the perched cistern (020) midway between the alum house and Saltwick Nab quarry, then the only circular cistern on the site is tank number 3, which lies on the lowest level of the alum house. The perched cistern is a vessel which almost certainly served as an intermediate store for raw liquor descending from the quarry. If tank number 3 did hold raw quarry liquor it would have to be pumped up to the pans. It does lie in close proximity to the site of the pans, but the the possibility should not be precluded that a similar, perhaps larger, vessel lies buried above the pans.

The position of the pans seems to be fairly clear. It is suggested by the intense reddening on the seaward face of the retaining wall, together with the presence of molten lead, broken iron plate and brick footings for suspending the pans over a hearth fuelled by small coal. What is not certain however is the precise arrangement of the pans against the wall, or how many were involved. The interval between the centres of the footings G,H,I and J is in each case about 6½ feet (2 metres). This may correspond with the approximate width of each pan, although the documentary sources suggest that a typical width of 5 feet (1.52 metres) was adopted. In 1774, when Saltwick was under the tenancy of Carr, Cookson & Company,[14] there were four pans operating, which arranged side by side would form a range measuring something like 20 to 25 feet in length (6 to 7.5 metres). However, the pans were probably arranged with gaps between to accommodate flights of steps leading to the upper working level around each pan. With an interval of say 2 metres between each pan the length of the range increases to about 15 metres. The actual length of reddening on the retaining wall measures about 17.5 metres; however, there may have been a surplus pan which could be brought into use when one was being repaired or renewed.

It is this conjectural arrangement of four pans which is shown on Figure 11. Each pan would have been heated separately from a furnace grate immediately beneath the pan. The heat from each furnace was applied to the base of each lead pan via an intervening iron plate and on the drawing the iron plate is shown on iron cross girders spanning between the brick walls.

These girders may also have supported the raised flagstone floor providing the working area between each pan. The exact cause of the reddening on the back wall is not clear, but the wall must have been in direct contact with the flame from each furnace. Perhaps the top of this wall carried firebrick vaulted flues leading to a central chimney, which would create a draught through each furnace.

Figure 11 becomes rather more tentative when one looks at the front of the pans. Each is shown with wing walls resting on the short lengths of footing marked M on the excavation plan. The wall marked K on Figure 10 is assumed to be the base of the front wall supporting the fire grate and fire door. Walls such as these would provide the furnace stokers (and the pans) with some protection from unregulated draughts. Similar wing walls can be found on an early 19th century engraving depicting the surface evaporators at Hurlet alum works in Scotland[15], although in this case the stoking area in front of the hearth was open to the elements and protected by an open-fronted shed with a pantile roof.

The justification for placing the wing walls on the footings M lies in the fact that each footing is aligned on the surviving lengths of brick footing marked G, H, I and J. It is assumed therefore that the two features are in some way related. However it is difficult to identify the role of the clay/sand terrace between the two features. The presence of yellow clay such as this usually indicates the former presence of a watertight cistern or tank, in which case the clay/sand terrace may have supported a flagged floor for a large rectangular tank beneath the pans. If so, the footings marked K may define the outer wall of this vessel and the footings marked M would serve as buttresses against this wall. The obvious problem with this interpretation is that it would leave little if any room for the housemen to stoke the furnaces beneath the pans. It is perhaps more realistic to assume that the clay/sand terrace has supported a level floor surface beneath the pans, laid with either flagstones, mortared firebrick or iron plate. A surface such as this could collect ash falling from the furnace grates before it was raked up and removed.

There is also evidence for burning at the south end of the site, at point O. Within the alum house several sources of heat would be required, for example initial clearing of the raw quarry liquor may have taken place within a large open lead pan suspended over a coal fire. Steam, generated from a coal-fired boiler, was also required for 'roaching' or purifying the crystals. The smooth operation of the alum house would also have required the services of a plumber, a blacksmith and a joiner, each requiring a source of heat. However, because this reddened wall lies adjacent to the yellow-stained culvert (P), it is likely to have been associated with an integral stage in the processing of the alum liquor. Careful monitoring of further evidence exposed by erosion is required to confirm this point.

Below the evaporating pans one would expect to find evidence of settling tanks for collecting iron oxide and iron silicate impurities precipitating out of the boiled liquor. After several hours the partially cleared liquor would then pass to large shallow cooling tanks where the addition of an alkali - either urine or kelp lees derived from burning seaweed and steeping the ashes in water - would cause crystallisation of the alum. These subsequent stages must relate to the evidence found on the lower level of the excavation, but precisely how is not clear. Tanks 1 and 2 are more likely to be cooling vessels due to their size and due to the fact that tank number 1 is sub-divided into two compartments, the smaller compartment perhaps holding the urine or potash alkali. One possibility that suggests itself is that the footings marked M are in fact the remains of a range of short narrow settling tanks arranged side by side with their lower ends sharing the back wall of tanks 1 and 2. There are obvious problems with this interpretation, notably the absence of any continuation of the footings M to meet with the back wall of the tanks. The excavation found no evidence for a flagged floor or puddled clay membrane between the footings, and instead found only purple-brown clay. However, one documentary source[16] refers to the use of lead-lined settlers for precipitating the impurities, so it is not inconceivable that movable lead vessels were inserted between the footings marked M. The problem would then be that little if any room was available for the housemen stoking the furnaces in front of the evaporating pans.

The conjectural reconstruction has excluded these settlers due to the lack of evidence to confirm their location. Instead the evaporating pans are shown connected with tanks 1 and 2 via a floor level culvert served by movable timber launder. The floor would lie immediately on the seaward side of the footings marked M. It is possible that tank number 1 served as the settler and tank number 2 as a cooler, but if this were the case one would expect to find more than one cooling vessel, because the first crystallisation would take several days to complete, whereas the evaporating pans were run off daily. What would seem more likely is that the hot liquor after settling was run into the lower compartment of tank number 1, where it was blended with alkali stored in the upper compartment and then conveyed into tank number 2. The transfer of liquor may have been assisted by pumping because the floor levels of the two tanks are very similar, that of tank number 2 lying only slightly below tank number 1.

After the crystals had formed they were scooped from the coolers, washed and then dissolved in steam or hot liquor and recrystallised. The latter process was known as 'roaching'. We have no evidence for these subsequent stages unless the upper compartment of tank number 1 served as a wash vat above the cooling/crystallisation compartment. There is always the possibility that tank number 3, the circular cistern, served as a storage vessel for either alkali or for waste 'mother liquor' remaining in the coolers after crystallisation.

The 'mothers' still contained a certain amount of aluminium sulphate in solution and a small proportion was usually added to each boiling of raw quarry liquor. As a cold solution it was used for washing the crystals from the coolers. The close proximity of the cistern to the evaporating pans and the presumed coolers, tanks numbers 1 and 2, might suggest its use as a mother liquor container, rather than a container for raw quarry liquor.

This discussion of the evidence from the excavation has been deliberately cautious about drawing firm conclusions since it is probably better to leave the evidence open for interpretation. However, we can be fairly certain about the site of the evaporating pans. What is not clear is the sequence in which the hot liquors would have passed through the tanks uncovered by the excavation. Nor is it clear how these liquors arrived, since, with the exception of culvert P, evidence of the means of liquor transfer is absent. It is probably safe to assume that a large amount of lead plumbing was involved, which was no doubt stripped out soon after the demise of the alum house at the turn of the 19th century.

It is almost certain that the excavated evidence, though fragmentary, corresponds with the group of three long sheds shown on Gibson's oblique view. These are clearly arranged in a descending sequence. Gibson's view probably does not exaggerate the number of chimneys to be found on the buildings. Assuming their construction to be typical of those found elsewhere, such as at Ravenscar, then they were almost certainly built as long sheds with double thickness sandstone walls covered by a pantile roof. Obviously it is important not to read too much into Gibson's view because it is very sketchy, but his illustration does suggest a compact and well ordered group of buildings belonging to a single phase of construction, rather than an organic growth of buildings characteristic of a long-established house such as that at Ravenscar.

EVIDENCE OF TRANSPORT AND COASTAL SHIPPING

The arrangement between the two Nabs of the various features associated with the Saltwick alum works reflects upon the opportunity for cheap bulk transport afforded by coastal shipping. Prior to Sir Hugh Cholmley gaining a licence to build a harbour in 1673, Saltwick had used a coal garth and staithes on the east side of Whitby town[17]. Some materials would also have been brought overland. Other alum sites on the coast were importing literally thousands of tons of coal each year for firing the evaporating pans, but because Saltwick adopted the novel arrangement of shipping its liquor to South Shields for evaporation then the port of Whitby must have been sufficiently close to facilitate the import of other raw materials. On the other hand, large volumes of raw alum liquor would have been exported since this would require some sort of infrastructure for loading and unloading vessels - ideally somewhere close to the edge of the Saltwick Nab quarry where the earliest liquor was produced. Perhaps the 'Old Pier' on Gibson's view served this purpose. What is not known is whether or not the raw liquor was concentrated before it was exported. The situation is likely to have changed after the construction of the alum house referred to by George Young, c.1770, when large volumes of coal would have been required and it would therefore seem likely that the massive breakwater enclosing the harbour around the alum house dates from this period. This assumption is supported by the obvious requirement of the alum house for protection from wave erosion.

There is of course a converse assumption which can be made i.e. that the decision to construct an alum house and its location were a response to a pre-existing harbour. However, it is a massive structure, requiring considerable financial commitment for its construction, and this is only likely to have come about as a response to a major stimulus, such as the completion of the alum house.

THE ALUM HOUSE BREAKWATER

Sufficient evidence still survives to define the extent of the massive breakwater (023) which formed a defence nearly 300 metres in length (Figure 8) around the seaward side of the alum house (at its closest point it comes to within about 70 metres of the seaward edge of the excavated area). It is built in two sections which together form a rough semi-circle around the alum house. The opposing inner ends of these two sections are slightly staggered and form a mouth 20 metres in width into the protected area behind the breakwater. There is a narrow channel of slightly deeper water forming the approach to this opening which can be seen under water at high tide under conditions of bright light. This channel extends out seawards for a distance of several hundred metres and seems to be a natural feature which has partially determined the location of the breakwater.

On both sections the outer edge of the wall is made up of massive blocks of reddish-brown ironstone up to 1.5 metres in length and 0.6-0.7 metres high laid directly onto the grey shale floor of the bay (Figure 13). The northernmost end of the north section is laid on a natural lip in the grey shale forming the floor of the bay. The lip stands to a height of 0.5 metres and tapers down to the south, yet its existence seems to have determined the positioning of much of the north section of the breakwater. The core of the wall behind the edging blocks is built-up of similar sized but irregular shaped blocks with smaller irregular rubblestone packing the gaps between the blocks. In one or two places there is surviving evidence to suggest that the packing is bonded with a grey lime mortar containing a high proportion of coal ash and an aggregate made up largely of burnt shale.

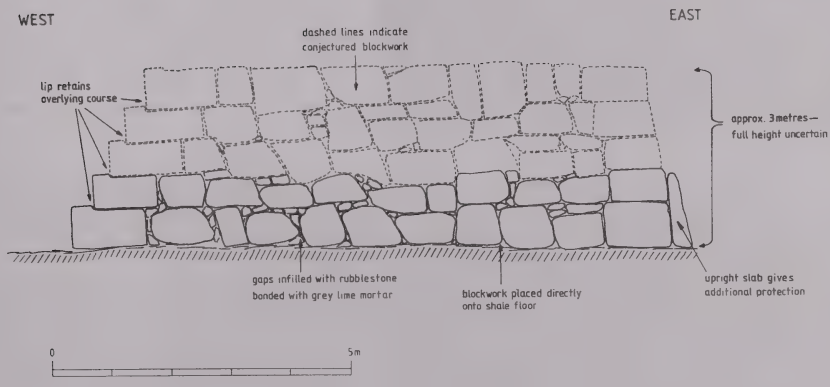

FIGURE 13 *Schematic section looking north across the north section of the alum house breakwater*

Over most of the north section only the foundation course survives, except on the south-west corner of the T-shaped mouth where a second course of blocks overlies the foundation course. The survival of this second course is possibly a consequence of this corner being more protected, although having said this much of the second course also survives on the end of the T-shaped section projecting into the sea. The south section of the breakwater is better preserved with much of the second course remaining. This is quite deliberately placed behind a lip on the underlying course which projects upwards to a height of 3-4 cms (Plate 7).

PLATE 7
Looking along part of the inner edge of the north section of the alum house breakwater.
Note the retaining 'lips' cut into the top of the blocks.
Scale 2 metres length

PLATE 8 *The outer vertical wall protecting the north section of the alum house breakwater (023). (Scale 2 metres length)*

The purpose of this lip is presumably to prevent the upper course from being dragged off the wall. Assuming the missing upper courses also sat behind a similar lip, this would create a successively stepped profile which would deflect the energy of any large wave hitting the breakwater. The surviving second course on the north section carries a similar projecting lip on its upper surface (Figure 13), thus confirming the former existence of a third course, and suggesting a minimum height to the overall structure of at least 1.8 metres.

The original height of the breakwater is difficult to determine, partly because the upper courses are now missing, but also because average sea level has probably changed since the construction of the harbour. Each high tide now submerges the entire outline of the breakwater. The presence of a vast amount of large masonry accumulated behind the breakwater and close to its seaward edge suggests that the present surviving structure is a bare remnant. Even so it is an impressive testimony to the scale of construction implemented to protect the alum house situated at the high water mark.

The north section of the breakwater differs slightly from the south section in that it has been given additional protection from the sea by placing massive upright slabs up to 1.4 metres in height against the outer edge of the northern end of this section (Plate 8). As this slab wall progresses southward it seems to move away from the main edge of the breakwater so that eventually it is separated by a gap of about 5 metres. This gap probably corresponds with an increase in the width of the breakwater, in which case prior to erosion the gap would originally have been infilled with irregular-shaped blocks. Its construction has probably given additional protection to this, the most vulnerable part of the breakwater.

The south end of the north section seems to have been restructured at the point where a line of blocks passes across its width and continues beyond its seaward edge for a distance of 23 metres. This T-shaped terminal is either an extension of the original north section, or more likely, a restructured terminal as a response to storm erosion. Its construction seems to have narrowed the width of the entrance into the protected water behind the breakwater, yet at the same time it would have afforded protection to small boats which would otherwise have been buffeted and pushed onto the end of the south section by waves driven by the prevailing northerly and north-easterly winds. In calm weather the seaward projection may also have provided additional short term quay space for boats unloading cargoes between tides. There is a line of timber stumps (024) set into square sockets leading away from the seaward angle of the T junction which may originally have supported an elevated timber stage used for unloading a boat berthed outside the north section of the breakwater. Some of these posts appear to be paired and it is likely that more remain to be discovered beneath the loose scatter of blocks derived from the erosion of the wall.

It is also worth highlighting two niches in the south face of the seaward section of the T since these may have held mooring posts for a small boat anchored within the angle of the terminal. Small boats such as cobbles would have been needed for hauling large vessels up to the face of the breakwater, and perhaps for trans-shipping cargoes from these boats when they were unable to get close to the breakwater if the tide was moving in the wrong direction.

The alignment of the timber posts just described points towards a second series of more substantial timber posts (025), each 25-30 cms square, set into rock cut sockets with small square blocks used to anchor the posts into the sockets. Eight of these stumps have been traced over a length of 29 metres and these are located at a distance of about 22 metres from the seaward face of the north section of the breakwater. The interval between each stump varies but averages about 3.4 metres.

The function of this outer series of posts remains uncertain but there are several possibilities. They may have provided an outer berth for the largest of vessels serving the alum house, such as collier briggs with a cargo capacity in excess of 100 tons. When loaded these would have had a draught of 10 to 12 feet of water which may not have been available close to the breakwater. The form of the berth can only be guessed at since only the stumps of the uprights remain but these are likely to have been braced with cross timbers. Even so, a simple cross-braced timber wall would have been insufficient on its own to provide a berth and a point at which to discharge and load a cargo and one must therefore speculate as to whether or not these postholes were part of a timber pier linked to the outer face of the breakwater. If this was the case one would expect to find more post stumps and sockets between the breakwater and the postholes. However, no such evidence to suggest a continuation has yet been found, although there are probably more timber stumps to be found within the outer part of the north section of the breakwater. If no such pier existed these additional stumps are likely to be mooring posts or rubbing posts for vessels actually berthing against the breakwater.

A second possible function for the postholes is that they formed part of an outer screen or cutwater for deflecting waves driven by the prevailing wind. However, this is pure speculation. Whatever their function, the alignment of the posts is highly irregular. Firm conclusions could perhaps be drawn if more post stumps were located - a likely possibility bearing in mind that the timbers on Figure 8 were observed and plotted on several successive visits.

There are several other features of interest associated with the breakwater which are worth mentioning. Three substantial timber posts (026), now surviving only as stumps, can be found close to the terminus of the south section. Their arrangement - in a triangle with a regular gap between their centres of 3.4 metres - and their slight inclination away from vertical,

suggests that they have formed a simple shearleg for hauling small boats out of the northern end of the protected water behind the breakwater. A similar function is normally served by rotating timber or iron capstans anchored into the top of a pier, but in this case the turning space within the protected water is so small that the stern of a small vessel could only be hauled from the point represented by the three timbers. However, they also appear to be in line with the centre of the alum house at the back of the protected water and this might suggest that a simple pulley was rigged up between the three timbers and a second shearleg close to the alum house. It would then be possible to haul items to and from the alum house without having to traverse the narrow causeway (022) which can be seen leading away from the interior face of the middle of the south section of the breakwater. If such a pulley existed it is likely to have been used in conjunction with the causeway because speed of loading and unloading was of the utmost importance to the master of a vessel who wished to avoid his ship becoming wrecked or stranded in shallow unpredictable waters.

A stone culvert (027) passes across the middle of the south section and emerges on its seaward edge. It appears to be incorporated into the foundation course of the breakwater and consists of a series of U-shaped stone blocks laid end-to-end forming a length of 5.1 metres which terminate against a large 2 metre square sandstone slab within the core of the breakwater.The channel cut along the centre of the blocks averages 12 cms in width and is cut to a depth of 10-11 cms This seems to be the only such culvert incorporated into the breakwater. Its incorporation into the foundation course is curious because this would provide a point of weakness in the overall structure of the breakwater, unless the upper courses were continued across the culvert. It seems to have drained away from the large sandstone slab, which has possibly acted as a support for a tank of liquor or water built into the thickness of the breakwater.

Towards the south end of the south section the width of the breakwater tapers down to about 6 metres and at this point there are two flush joints running across the blockwork, separated by a gap of 6.5 metres. The sandstone used to fill the gap has a yellow colour as against the brown-purple colour of the surrounding blockwork. It would appear therefore that the gap was originally open and lined on its south side with three upright timbers (028) which still partially survive as stumps. The purpose of the gap may have been to provide a route for horses and horse-drawn carts travelling across the rocks to and from the Black Nab quarry at low water. At high water it may also have been possible for small boats to pass through the gap and the timbers would have prevented any boat from being dashed against the side of the breakwater. However, it would provide a point of weakness within the breakwater and for this reason it was probably blocked. It is also conceivable that the tapered section beyond the first flush section is a later

addition, built to improve the defensive capability of the breakwater at its extreme south end.

THE INNER QUAY

Behind the north section of the outer breakwater there is a second line of large sandstone blocks (029) laid side-by-side over a length of 78 metres. These run roughly parallel with the base of the cliff on a north-south alignment, starting from a point close to the tip of the north section and ending almost in line with the perched circular cistern (020). The south end then turns sharply to the south-west and continues across the beach for a distance of 21 metres. The individual blocks are of a similar size to those on the outer breakwater but there is only a single course surviving and these do not carry any evidence of a projecting lip to retain a missing upper course. There is however, a similar core of smaller irregular blocks behind these large blocks which appear to be secured with a concreted mix of burnt shale, sand and lime. This concretious mix can be found as a broad raft laid over much of the rock behind the blocks, and also in patches on the seaward side of the blocks.

The occurrence of this concretious raft is not unique to Saltwick. Similar rafts made up largely of burnt shale can be found on the rocks below the Boulby and Kettleness quarries. All three sites would have dumped the burnt red shale from the steeping pits in the quarries over the cliffs and the presence of lime within the shale would have caused it to consolidate after reacting chemically with the salt in the seawater. Whether or not this material was deliberately dumped around the inner breakwater remains uncertain, but it is perhaps more than coincidence that this is the only place where it survives at Saltwick. It may have been placed to create a crude surface behind the line of blocks, thereby protecting the base of the cliffs and the circular cistern from erosion. There is a second short 17 metre length of blocks (030) running parallel with the inner breakwater which may have held back a second outer raft of concretious shale. If so, there is now very little of this outer section surviving.

There are two further short lengths of block (031 and 032) leading away tangentially from the back edge of the curved line of blocks. Both are about 10 metres in length and laid on the grey rock floor of the bay. The more southerly line (031) is a single course of blocks up to 0.65 metres in height which reaches to the back of the curved line. The more northerly line (032) is also a single course, but probably badly eroded, perhaps extending originally to the back of the north section of the main breakwater. Between the two lengths there is a very substantial platform of concretious shale. It is worth noting that a similar short 4 metre length of single course blockwork (033) extends back from the middle of the north section of the outer breakwater. The latter may be the remnant of a short

causeway, similar to that linking the south section with the alum house, although in this case it would link the north section with the curved inner breakwater.

The purpose of the curved inner breakwater is uncertain, especially since it lies at an acute angle to the outer breakwater. It would undoubtedly have provided protection to the base of the cliffs carrying the circular cistern (020) and perhaps a liquor trough from the Saltwick quarry. The other possibility is that it served as a primitive quay for boats coming to the foot of the cliffs at high tide, if so it must have been more substantial and comprised more than a single course of blocks. Evidence in the form of a projecting lip on the surviving course would confirm this, but there is no such lip. There is however, a single large timber post projecting from the south corner of the curved line of blocks, possibly the remnant of a mooring post or a rubbing post. The cramped arrangement of the inner breakwater behind the outer breakwater seems to suggest that the two features are not contemporary and after the construction of the outer breakwater the inner length was all but inaccessible, except to small boats.

At this point it is worth noting that Gibson's 1780s view depicts a short feature labelled as 'Ruins of a Pier' projecting from the base of the cliffs at about this point. The inner breakwater may well correspond with this feature on Gibson's view, in which case the isolated short length of blocks could be the remnant of a seaward projection on the pier. The whole interpretation is tenuous because continuous erosion over nearly 200 years has left only fragmentary evidence. It may not be a coincidence though that the inner breakwater lies below the perched circular cistern. Liquor generated in the steeping pits of the Saltwick Nab quarry could have been conveyed by gravity to this cistern before it was barrelled and loaded into sloops waiting to take it to South Shields for evaporation and crystallisation.

BLACK NAB BREAKWATER

The exposed seaward edge of the Black Nab quarry was protected during its period of operation by a substantial breakwater (034 and 035) erected on the north-east and north-west corners of the quarry. The large number of blocks from this feature, now strewn across the rocks, attest to its former size and the effort that must have gone into its construction. The two sections remained joined until at least 1854 when the first edition of the Ordnance Survey 6 inch scale map was published . However, the second edition of the Ordnance Survey 25 inch scale map shows the two structures separated by a slight projection of the quarry and by this date (1913) the Nab was already separated from the main body of the quarry.

The north-west corner section of the breakwater (035) is a massive two-sided structure erected against the face of a lower

terrace of shale overlooked by the leading edge of the quarry (Figure 5 and Plate 2). It is built of massive cubed blocks of ironstone placed in a similar manner to the breakwater skirting the alum house i.e. with the upper course stepped back slightly behind a projecting lip on the top of the lower course. The north face survives to a height of three courses or just over 2 metres over a length of 45 metres and the right-angled return to the west survives to a similar height over a length of 23 metres. Originally it would have extended back to the leading edge of the quarry but wave erosion has obviously been concentrated in this corner. Behind the two faces blocks of a similar size, but a less regular shape, have been placed to support the two leading edges. Reference has already been made to a massive block of loose stone nearly 1.5 metres in length which carries the initials I+S+ and the date 1766 (Figure 7). It has evidently been pulled away from the leading edge of the breakwater and provides a fairly certain date for the construction of the breakwater, and probably for the development of the Black Nab quarry. There is a second block of loose stone slightly below the corner of the two faces which carries a smaller inscribed 'I' and this could well be a mason's mark.

The north-east corner of the breakwater (034) remains only as a single course of massive blocks, although a missing second course is confirmed by the survival of several upper blocks on the east corner of the structure. A very shallow lip can be traced on the upper surface of some of the blocks. Otherwise it stands to a height of 0.65 metres over a length of 35 metres and has a consistent width of 2.9 metres. This section differs slightly from the north-west section in that it stands isolated from the leading edge of the quarry on a very slight lip in the grey shale forming the floor of the bay. Its isolated position seems to suggest that following the decay of the breakwater the base of the quarry has subsequently been eroded. It is interesting to note that the back edge nearest the quarry is straight and perhaps originally was built against the base of the forward edge of the quarry. The east end forms a short right-angled return to the south, implying that it was built around a projection of the quarry which has since been eroded.

The surviving length is built in a similar manner to the north-west section with irregular shaped blocks placed behind the leading edge and the gaps packed with smaller rubblestone. Several of the blocks carry small square sockets (averaging 5cms x 5cms) in their top surface. These may be Lewis holes for lifting the blocks out of the quarry and into position, or they may be sockets for missing iron bands which would clamp each block with the adjacent block.

Whether or not these two breakwaters were used as moorings remains uncertain, but it would seem unlikely, other than for small boats with a very shallow draught because the grey shale floor gradually steps up as it approaches the two breakwaters, so there would be little depth of water at high tide. Several groups of post stumps set into sockets surrounding the

breakwaters may have acted either as moorings or navigation posts, but the main berth serving the Black Nab quarry seems to have been an inlet (036) cut into the rock close to the west side of the outer Nab. This is described at the end of this section.

There is a long line of 27 post stumps (037) running virtually parallel with the north-east section of the breakwater over a length of 60 metres. These stumps are almost certainly contemporary with the breakwater because their alignment assumes the same right-angled return around the east end of the breakwater. The north-west end of the line continues beyond the remnant of the breakwater for a distance of about 20 metres, suggesting that a corresponding length of about 20 metres is now missing from the breakwater. At their closest point they are separated by a gap of 9.5 metres from the north face of the breakwater, and 6.65 metres from its east face. The intervals between the centres of the stumps vary from 1.75 metres to 2.24 metres. Most of the timbers appear to be square in section, set within sockets varying from 0.3 to 0.35 metres square. The individual post stumps are smaller than the actual socket size and smaller pieces of timber packing have therefore been used to wedge each post firm.

The presence of these stumps seems to suggest that some sort of staging was erected in front of the breakwater, perhaps to serve as a simple walkway for loading and unloading boats. However, if this was the case one would expect a more rigid structure with at least a further line of posts providing additional support. Alternatively the posts may have been part of a protective screen or groin, providing the first line of defence against wave erosion, although again, one would expect more substantial posts for such a function. Because they may have been inadequate the breakwater was possibly built to replace the timber groin, its position on the landward side of the posts indicating the rapid rate of erosion occurring at the base of the quarry.

The remaining group of posts and sockets around the Black Nab breakwater assume a more random arrangement but they are likely to be contemporary with the operation of the quarry. There are two groups of three sockets (038) arranged in two equilateral triangles on either side of a slight spur of raised shale forming the end of the quarry projection. The more westerly group are of an even size, but two of the three on the east side measure nearly 0.5 metres square and have clearly held substantial timbers, perhaps acting as mooring posts. In front of the north-west section of the breakwater there is a narrow rectangular slot (039) cut into the rock, 2.85 metres in length and 0.68 metres wide at the north-west end, tapering to 0.55 metres at the other end, containing three equally spaced timber stumps. Two similar slots can be found close to the long line of stumps. One of these contains a single line of large stone blocks (040), the other (041) carries neither posts nor blocks and may in fact be a natural feature, although it is more likely to have held blocks which are now missing. Again, it is

difficult to identify a function for these features, other than to suggest that small boats would have been moored here and larger boats may have been guided to the outer inlet (036) by navigation posts set into some of these sockets.

The wreck (042) below the northern tip of the quarry is the remains of a trawler washed ashore in a gale during the late 1970s with the loss of its crew.

BLACK NAB DOCK

The feature labelled as a 'Dock' (036) on the west side of Black Nab (Figure 5) has been identified with some degree of certainty as a natural channel which has been been deliberately enlarged to create an inlet for boats. It would appear that the south and east edges of the channel have been cut back and straightened to provide a shallow berth measuring approximately 35 metres in length and 10 in metres width. It is significant that the inlet remains filled with water at low tide because at high tide the entire rock surface up to the face of the two breakwaters is concealed so boats berthed in the dock could only be unloaded at low tide.

The likelihood of its being used as a berth is supported by the survival of a number of post hole sockets leading away from the south and east edges of the inlet. Leading away from the east edge over a length of about 5 metres there are 6 sockets in a staggered line (043), 5 of which have square outlines between 0.35 m x 0.35 m and 0.5 m x 0.5 m, but one with a rectangular outline 0.8 m in length and 0.44 m wide. These seem to lead towards the outer part of the Nab and suggest the position of an elevated walkway which might allow a cargo to be unloaded at deck level. There are several more sockets of a similar size either side of this line and then an irregular group of 7 sockets (044) scattered around the southern edge of the inlet without any obvious pattern or regularity of size.

A third group, this time arranged in an L-shaped pattern (045), can be found midway between the inlet and the north-west section of the breakwater. The north-south arm of this L comprises four evenly-spaced sockets, each approximately 0.4 metres square. There are two further square section sockets forming the base of this shape, each of a similar size. Again, it is difficult to draw firm conclusions about the function of these posts, but it is worth noting that they point towards the line of six close to the dock and point towards the middle of the north-west breakwater. Perhaps they could indicate the position of an aerial ropeway used for hauling light goods to or from the quarry? What is perhaps surprising is that there are no 'rutways' used for guiding the wheels of horse-drawn carts from the margins of the dock towards either the Black Nab quarry or the alum house situated midway in the bay.

MISCELLANEOUS STRUCTURES AROUND SALTWICK NAB

The remains of several 'rutways' can be found on either side of Saltwick Nab leading away from the furthest extent of rock exposed at low tide. Rutways on the Yorkshire and Cleveland coast were first positively identified by John Owen in the late 1970s[18] and since then a number of examples have been recorded at sites associated with the production of alum and the mining of ironstone on the coast. Each rutway consists of a pair of shallow grooves cut and worn into the rock floor, usually to a depth of several centimetres, although several examples can be found at Ravenscar (NZ 973024) where the rock has been cut to a depth of up to 0.5 metres to allow each cart to ascend across the terraced profile of the bay floor. What is particularly remarkable about these rutways is that the gauge between the inner edges of the ruts is consistently close to 1.2 metres and the variation is never more than several centimetres. The purpose of initially cutting the ruts seems to have been to guide the wheels of horse-drawn carts across the most suitable route over the rock and they would prove most valuable either as the tide was beginning to turn over the rocks again, or at night, or in foggy conditions when the route might not be obvious. The absence of such rutways around the Black Nab dock might suggest that at least some of the post stumps indicate where lamps were hung to guide cargoes drawn at night.

The rutways on the west side of the Nab (046) have not been surveyed because they remain covered by water at low tide and are therefore difficult to trace. Their alignment lies parallel with the Nab, heading towards the base of the north-west corner of the quarry. This seems to suggest that cargoes were raised and lowered from the edge of the quarry.

On the east side of Saltwick Nab two rutways have been found. The longest of these (047) can be traced over a distance of about 70 metres across the middle of the rock floor, midway between the tip of the Nab and the north section of the alum house breakwater (Figure 2 and Plate 9). It would appear to be providing a route towards the alum house from the outer margin of rock exposed at low tide which lies just beyond the tip of the Nab. Gibson's oblique view shows a channel of deep water called the 'Sleadway' leading towards this outer margin of rock and it would seem likely that boats heading for this point could use the channel when making the approach to or from Whitby. There is also the possibility that kelp - used as a source of potash in the production of the alum crystal - was gathered from this low water margin and brought across to the alum house by horse and cart.

The second rutway (048) on the east side of the Nab lies not on the rock floor of the bay, but rather on a raised slipway or ramp built of massive stone blocks (Figure 3 and Plate 10). The structure in question is labelled as 'Old Slipway' on the second edition of the Ordnance Survey 25 inch map dating from 1913 but does not appear on the first edition of the 6 inch map

PLATE 9 *Looking north towards Saltwick Nab with rutway (047) in the centre of the photograph. (Scales 1 metre length)*

PLATE 10 *The slipway below Saltwick Nab (048). The rutway running along its top surface is just visible. (Scales 1 metre length)*

(1854). Whether or not it is contemporary with the period of alum production remains uncertain. If it is then it must date to before c.1800, in which case it is a remarkable survival, bearing in mind the degree of erosion to the alum house breakwater. On the other hand it may have been erected during the first half of the 19th century - for unloading coal for local domestic use, or perhaps for loading seaweed collected at the low water margin. Coal may also have been used for firing a limekiln which is located on the 1854 map at the base of the cliffs midway between the two Nabs. Evidence for the kiln is described in the following section.

The slipway is made up of a series of stone blocks laid on edge side-by-side which gradually increase in depth to form an ascending ramp, increasing in height from 0.3 metres at its south-east end to 1.1 metres at the north-west end. The north-west end incorporates a second course of blocks which raises the height to 1.1 metres. The width of the structure increases from 1.95 metres to 3.3 metres as it ascends and it has an overall length of 12.5 metres.

The rutway has the standard gauge of 1.2 metres and this is cut to a depth of 15-20 cms into the entire length of the top surface of the blocks making up the slipway. It is noticeable that the base of the cuts are well rounded, suggesting that they have been heavily worn by iron rimmed cart wheels. What is perhaps rather surprising is that the ruts do not continue across the rock beyond the base of the slipway and indeed, the isolated situation of the slipway midway across the rock floor of the bay seems to be rather curious because the whole structure is quickly covered by a returning tide and could therefore only be used at low water. It is built upon a platform of rock raised slightly above the general floor level of the bay and it is also worth noting that there is a shallow channel below its north-west end which would provide a slight increase in the depth of water. If horse drawn carts ascended onto the slipway they would have to be backed up. It is therefore perhaps not surprising that the ruts are so deep because they would have to guide the wheels of the cart. This seems to suggest that empty carts were pushed up to the end of the slipway, loaded from the deck of a vessel which had navigated up to it on a receding tide, and then drawn away down the slope, either to the alum house or to the edge of the Saltwick Nab quarry.

THE LIME KILN

Reference has already been made to the inclusion of a lime kiln on the 1854 Ordnance Survey 6 inch map and this seems to suggest that industrial activity continued on a minor scale within Saltwick Bay after the period of alum production.

The position of the kiln on the map is indicated by a small circle which is placed at the base of the cliffs, close to the point where a 'Watering Trough' empties its contents onto the beach. The watering trough almost certainly corresponds with the contents of a field drain which now emerges from a pipe at the top of the cliffs and descends down the cliffs before emerging onto the beach at a point just inside the end of the south section of the breakwater. The remains of the kiln (049) are situated at the foot of the boulder clay cliffs, about 30 metres west of high water mark and midway between the lowest point of the stream and the southern end of the alum house (Figure 8). Very little of this structure is now visible and it would be difficult to interpret its function without the evidence recorded on the 1854 map. What can be seen is a short straight length of wall - slightly more than 3 metres - standing to a minimum height of three/four sandstone courses above the present ground level. The lowest course disappears into the ground and it is clear that the wall continues down to an unknown depth. It is also clear that the the two ends also disappear into the ground so that the full length of the wall is not evident. The lower two courses are level and incorporate occasional throughstones. The upper two courses are apparent at the south end of the wall but are replaced by single blocks laid vertically on their ends.

It would appear that the change in character of the upper two courses results in a gradual increase in the height of the wall towards its south end. This suggests that the structure constitutes a ramp, but what it leads up to, or perhaps leads down to, is uncertain. Assuming it to be associated with the kiln one would expect to find a charging ramp providing a means of backing up a horse drawn cart laden with coal or limestone to the mouth of the kiln. Unfortunately, because each end of the wall disappears into the ground it is difficult to say what it leads to. The problem of interpreting this structure is compounded by the fact that it has probably subsided as the boulder clay has slumped forwards towards the beach. Evidence for the movement of this clay can be seen lower down the slope closer to the beach where a deep gully has formed as a consequence of the leading edge of the clay breaking away. If the kiln has slumped forwards this implies that its use would entail bringing coal up a steep slope from beach level. Limestone was available in the upper layers of the cliffs and could therefore be lowered down but the delivery of coal could not be so easily managed. If the kiln was fired after the demise of the alum house this would suggest that the harbour encompassed by the large breakwater continued in use into the 19th century.

CONCLUSIONS

The importance of the physical remains at Saltwick is underlined by the fact that so little physical evidence survives from any of the thirty or so sites formerly producing alum in North-East Yorkshire. This is true in spite of the relatively recent demise of the coastal sites i.e. Peak, Boulby, Loftus, Sandsend and Kettleness where the output of alum continued into the second half of the 19th century. What is therefore needed is a corpus of evidence from these sites to illustrate the complex, inter-related processes of raw liquor production, crystallisation and subsequent transport of the finished crystal.

Saltwick retains important detailed evidence illustrating all three aspects, perhaps more effectively than any other site, although if one particular attribute stands out it is the extent of evidence illustrating arrangements for coastal transport of raw materials and finished alum. The arrangement of this evidence within the landscape reflects upon the advantages of Saltwick's landscape setting, especially the advantage of a sheltered site for the alum house, which was served directly by ships mooring within the bay. Quarrying of shale on the two Nabs meant that overburden and waste shale from the steeping pits could be conveniently discarded over the edge of the two quarries into the sea, whilst liquor generated from these two sources could be run directly by gravity to the beach level alum house. Saltwick also had the obvious advantage of a location close to the port of Whitby, which could supply ships for transportation, as well as raw materials, and perhaps a supply of labour for the quarries and the alum house.

Furthermore, whilst highlighting the significance of the Saltwick evidence, it is important to bear in mind that no two sites would adopt the same physical arrangement to facilitate liquor production, crystallisation and subsequent transportation. Landscape setting and the initiative of the individual proprietors in developing and implementing new techniques of production were likely to be important variables. The latter factor is particularly pertinent to the Saltwick alum works since the Cholmleys were the only producers to realise the economic advantages of shipping liquor rather than coal in bulk. As a consequence it is therefore possible to find evidence that is unique to the industry at this site, such as the liquor pit on the edge of Saltwick Nab quarry. Other sites such as Peak and Loftus still retain evidence of artificial docks and breakwaters to facilitate coastal transport, but the scale of this evidence is nothing like the elaborate breakwaters and piers erected at Saltwick.

It would be interesting to know to what extent this initiative on the part of the Cholmleys was determined by Saltwick's advantageous landscape setting. There was a strong element of competition between the various concerns and this would stimulate any initiative likely to result in a competitive edge

over production costs. If Young is correct in stating that Saltwick did not have an alum house until about 1770 one can only assume that once adopted, the arrangement of shipping liquors to South Shields must have remained profitable and tenable for more than 100 years. On the other hand, the cost of having to erect an alum house from scratch must have seemed daunting to any proprietor. Usually such buildings constituted an 'organic' growth of structures, erected piecemeal as innovations in technique were introduced, or as extra capacity was required. The cost of building from scratch might explain why the alum house came so late to Saltwick and it is perhaps not a coincidence that when it did arrive it was at the start of the most prosperous period for Yorkshire's alum industry, although having said this by 1774 Saltwick had entered into a manufacturing agreement and was using only four pans.

Clearly there are risks in relying too closely on a single source of documentary evidence i.e. George Young's account of the alum industry. The large breakwater around the alum house is assumed to be contemporary with the construction of the house since it encircles and protects this structure, in which case, according to Young this would date the breakwater to about 1770. However, we have a reference for a licence to build a harbour which was issued in 1673, and this could well be the structure in question. If so, the cost of building such a structure must be seen as a major capital commitment on the part of the Cholmleys, especially since annual tonnages of alum produced during the second half of the 17th century were relatively low. If it was already in existence by 1770 this would suggest that the siting of the new alum house was partially determined by the protection afforded by the breakwater, although the significance of its location midway between the two quarries should also be stressed. The absence of dateable evidence remains one of the most intractable problems frustrating the interpretation of the Saltwick site and because of its absence one is left to draw conclusions by assuming chronological relationships between the various features, as outlined by the example of the breakwater.

The other source of frustration of course is the fragmentary state of the evidence. It is important to stress that many of the conclusions are tenuous and should remain open for discussion, especially those attempting to explain the pattern of berthing within the bay. Evidence illustrating the theme of coastal transport is to be found in the most marginal locations in the bay and all too often it was erected from the least resilient materials i.e. timber. The excavation of the alum house has furnished a greater depth of detail relating to a single feature, although even here evidence for the advanced stages of crystallisation is missing and we have to assume its existence. Its absence however, might imply that the excavated structure was involved only with concentrating the liquor, rather than bringing it to a final stage of crystallisation.

The evaluation of the Saltwick alum house was conceived primarily as a recording exercise in response to the continuing

loss of evidence unique to Yorkshire's former alum industry. During the two and a half year period between the start of the evaluation and the completion of this report erosion by wind, by wave, and to some extent by human interference has continued to strip away structural evidence from the alum house at an alarmingly rapid rate, although on a more positive note it has also revealed evidence which has helped to substantiate certain conclusions concerning the functional relationship between features on this site. The task of recovering, recording and interpreting this evidence appeared daunting at the outset but viewed retrospectively it is safe to assume that much, if not all of the threatened evidence within the inter-tidal zone has been recorded. Much though still remains concealed above the high water mark, especially beneath the slumped clay at the foot of the cliffs. In the future therefore the need remains to be vigilant about monitoring and recording further evidence as it comes to light, especially during the winter season when high tides driven by gale force winds can strip away unique evidence that has survived in a precarious marginal environment for more than 200 years.

The threat of erosion is not restricted to Saltwick alone but affects all the coastal alum sites where much of the processing took place in extreme marginal environments. Surviving evidence of the alum industry is already highly fragmented and no single site retains sufficient evidence to illustrate the processes involved. A complete picture can only be built up if a comprehensive programme of archaeological research and recording is implemented, covering all the coastal sites as a priority, but ultimately embracing all the Yorkshire alum sites. The archaeological evaluation at Saltwick has gone some way towards addressing this problem and has perhaps established a strategy for recording that could be applied to other threatened sites. In addition to this work at Saltwick, archaeological recording to diverse methodologies and standards has been carried out at Ravenscar (the National Trust), Stoupe Brow (Alum Research Group), Sandsend (David Pybus), Boulby (Cleveland Industrial Archaeology Society and The Royal Commission on Historical Monuments) and Hummersea (Cleveland County Archaeology Unit).What is required is for this work to be drawn together and a strategy of recording and research to a consistent methodology formulated leading to a comprehensive publication which would present and interpret thematically the various strands of evidence relating to Yorkshire's former alum industry.

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APPENDIX A

Plant and invertebrate remains from a cistern on the foreshore at Saltwick, North Yorkshire

A sample of sediment from the basal fill of a stone-lined cistern was submitted for analysis of plant and invertebrate remains. The sediment was described in the laboratory using a standard pro forma and a subsample processed using techniques described by Kenward et al (1980), involving disaggregation, sieving to 300 μm and paraffin flotation.

The sample consisted of light to mid grey, moist, plastic to sticky clay silt with wood fragments, occasional fragments of herbaceous plant detritus and what appeared to be fine charcoal. The 1 kg subsample did not disaggregate easily so it was treated with dilute sodium pyrophosphate to accelerate the process. The residue left after disaggregation consisted mainly of wood fragments, many of them splinter-like, the largest about 50 x 20 x 5 mm, with a very pale colour and fresh appearance. Two of the largest fragments were identified as pine (*Pinus* sp) and ?spruce (cf *Picea abies*). With the wood were a few small fragments of bark, a little coal (to 10 mm), brick/tile (to 25 mm), a piece of flint (to 15 mm) and a few small stone chippings, a little sand and traces of ?glassy slag, burnt clay and charred organic material (not charcoal).

The flot from paraffin flotation was very small and included only small quantities of insect remains which, however, were very well preserved. Thirteen beetle and bug species were recorded as adults, only *Cryptophagus* species being represented by more than one individual. There was a mixture of species associated with decomposing matter and species found in open air habitats including disturbed places. A single tentatively identified *Tipnus unicolor*, a spider beetle typically associated with old buildings, was the only very strongly synanthropic species. These remains give no clear evidence as to the way the deposit built up.

There was a single whole beetle larva, whose condition suggested a very recent origin, identified as probably belonging to the family Haliplidae. Likewise, a grass spikelet of very fresh appearance was also observed. These may have been contaminants during sampling.

Identifiable plant remains in the residue were few but mostly quite well preserved. There was a fragment of wheat (*Triticum*) rachis internode and glume base from an ear of this cereal, a leaf of the peatland plant cross-leaved heath (*Erica tetralix*), a tiny frond fragment of bracken (*Pteridium aquilinum*) and a moss leaf tentatively identified as *Pleurozium schreberi*. These remains seem most likely to have originated in some kind

of litter, perhaps from a nearby building, or perhaps in fuel, but the assemblage is really too small for more than speculation.

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