



# NAA

CONISTON COPPER PROJECT  
COMMUNITY EXCAVATION

PENNY RIGG COPPER MILL,  
CONISTON, CUMBRIA

on behalf of

LDNPA

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Manager	Penny Middleton
Draft	John Pickin, John Pickin Archaeology and Heritage Services
Graphics	Oskar Sveinbjarnarson and Catherine Chisman
Edit	Frederick Foulds, Penny Middleton
Authorised	Frederick Foulds
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Author John Pickin, John Pickin Archaeology and Heritage Services  
 Photographs John Pickin and Kate Chapman  
 Illustrations Oskar Sveinbjarnarson, Catherine Chisman and Kate Chapman

Client Lake District National Park Authority  
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**CONISTON COPPER PROJECT COMMUNITY EXCAVATION  
PENNY RIGG COPPER MILL, CONISTON, CUMBRIA  
ARCHAEOLOGICAL EVALUATION REPORT**

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**CONISTON COPPER PROJECT COMMUNITY EXCAVATION  
PENNY RIGG COPPER MILL, CONISTON, CUMBRIA  
ARCHAEOLOGICAL EVALUATION**

***Summary***

*This report presents the findings of archaeological investigations carried out at the Penny Rigg copper mill, Coniston, Cumbria during April 2017. The work, which comprised three evaluation trenches, was carried out by Northern Archaeological Associates Ltd (NAA), along with John Pickin Archaeology and Heritage, on behalf of the Lake District National Park Authority, as part of the Coniston Copper project. The aim of the excavation was two-fold: to provide training in archaeological excavation and recording techniques to local volunteers; and to address some questions of interpretation raised during the community survey of the mill complex carried out in 2016.*

*The Penny Rigg copper mill is a prime example of a single-phase, medium sized, ore dressing and processing plant, associated with the 19th-century working of the Tilberthwaite copper mine. It was constructed around 1860 to process copper from Horse Crag Level; a mine adit driven in the 1850s to intersect and drain the deeper parts of Tilberthwaite mine. The mine and mill remained in production until 1875, after which it was worked intermittently until the mid-1890s. In 1897, the copper mill was dismantled, and the water wheel was sold for scrap.*

*Excavation within the mill's crusher house found the remains of a well-preserved flagstone floor and evidence for a substantial timber structure, which probably supported the cast iron crushing rolls and associated equipment. Excavation within the probable jig house—the building where crushed ore underwent further concentration—uncovered a cobbled surface constructed above an artificial terrace. The presence of processed mineral waste, and the discovery of a fragment of metalwork from a jig, confirmed the use of this building as a jig house. A third trench excavated within a possible building platform proved inconclusive.*

***Acknowledgements***

NAA would like to thank all the Penny Rigg volunteers for their enthusiasm, dedication and good humour throughout the excavation. Particular thanks, as ever, go to Warren Allison and the members of CATMHS, Eleanor Kingston and her colleagues at the LDPNA, and Mike Mitchell for permission to use his drone footage.

## 1.0 INTRODUCTION

- 1.1 This report presents the findings of an archaeological evaluation carried out at the Penny Rigg copper mill, Coniston, Cumbria in April 2017. The work, which comprised three evaluation trenches, was carried out by Northern Archaeological Associates Ltd (NAA) with John Pickin Archaeology and Heritage (JPAH) on behalf of the Lake District National Park Authority as part of their Coniston Copper project. The project involved a number of local volunteers in the excavation and recording of the archaeological remains.
- 1.2 The evaluation ran over a period of five days—from the 24th to the 28th of April 2017—and was attended by 29 volunteers. The weather, although bracing, was generally good.
- 1.3 All archaeological works were undertaken in accordance with relevant standards and guidance published by English Heritage (2008), Historic England (2015) and the Chartered Institute for Archaeologists (2014a; 2014b; 2014c).



*Plate 1: general view of the mill complex from the east. The crusher house and water wheel pit are top centre with the jig house below. (Image courtesy of Mike Mitchell).*

## 2.0 LOCATION, TOPOGRAPHY AND GEOLOGY

### Location

- 2.1 The evaluation was carried out at the Penny Rigg copper mill (NGR: NY 30656

00695), which is located c.3km north-east of Coniston village. It is separated from Tilberthwaite Fell to the north-west by Tilberthwaite Gill; this is joined at Low Tilberthwaite by Yewdale Beck, which runs along the east side of the site (Figs. 1 and 2). The mill is situated c.300m south of the quarry car park, on the west side of the road leading from the A593 to Tilberthwaite Farm. The complex occupies an east-facing slope, the highest point (at the base of Horse Crag) being 183m above Ordnance Datum (aOD), dropping to 144m aOD on the road south of the building.

### **Geology and soils**

- 2.2 The underlying geology comprises basaltic-andesites of the Borrowdale Sill Suite, part of the Borrowdale Volcanic Group, which formed 451 to 461 million years ago in the Ordovician period (BGS 2018). The superficial deposits have not been recorded but are likely to be thin glacial sands and gravels.

## **3.0 SUMMARY ARCHAEOLOGICAL AND HISTORICAL BACKGROUND**

- 3.1 The archaeological and historical background to the mine and mill is discussed at length in the two community survey reports (NAA 2016; 2018), and only a summary of information relevant to the archaeological investigations is given in this section.
- 3.2 Penny Rigg copper mill is a prime example of a single-phase, medium sized, ore dressing and processing plant, associated with the 19th-century working of the Tilberthwaite copper mine (NGR: NY 30646 00722). Tilberthwaite had been worked sporadically since the Elizabethan period but was prone to flooding, making it unprofitable and problematic to work. In 1849, work began on the construction of a low-level mine adit—Horse Crag Level—under the direction of John Barratt, former manager and later share holder of the nearby Coniston copper mine. The aim was to drive the new adit to intersect and drain the lower levels of the North Vein at Tilberthwaite mine, as well as improve transport out of the mine. Estimated and costed to take three years, it eventually took nearly ten years to complete.
- 3.3 To process ore from the venture, Barratt and his partners invested in the construction of a new copper mill at Penny Rigg, where the ore was to be sorted, crushed and processed before being sent for smelting. The mine and mill remained in production until 1875, when both were sold—along with the Coniston Mine—to Thomas Wynne. It was subsequently worked intermittently until the end of the 19th century but was never really profitable. In 1891, following an extensive roof collapse, the level was

finally abandoned. The then owner, Thomas Warsop, turned his interests instead to slate quarrying, re-opening Penny Rigg quarry in 1892 and beginning work on a closehead quarry at the entrance to Horse Crag Level. By the mid-1890s, the mill had been abandoned, and in 1897 the water wheel was sold for scrap. In 1901, the roof of the mill was removed and reused on a terrace of shops in Coniston village (Cameron and Withey 2017, 81).

- 3.4 In the early 20th century, the mine was briefly re-opened, but closed again in 1933, after which all production at the mine ceased. The quarry continued to operate, under the auspices of Oscar Gnospelius and his agent John W. Shaw, until 1938. More recently, in 1989, George Tarr obtained planning permission to re-open the closehead slate quarry in Horse Crag Level, working the site for ten years until it closed in 2000. There has been no activity onsite since this date.
- 3.5 Today the 1.5ha site comprises the semi-ruinous remains of the crusher and jig house, smithy and powder house, as well as various terraces, two settling ponds, leats, spoil tips and tracks. These are overlain in part by extensive tips of quarry waste (rid tips) on the west side of the site. The entrance to Horse Crag Level is still clearly visible and has recently been cleared by members of the Cumbria Amenity Trust Mining History Society (CATMHS). To the north of the site are the expansive remains of Penny Rigg (Horse Crag) slate quarry, worked commercially since at the 18th century (Fig. 2).

### **Previous work**

- 3.6 A survey of the mill was undertaken by members of CATHMS in 1999 (NAA 2016, Appendix 2), and in 2010 a Conservation Plan of the mill, mine levels and slate quarry was prepared by Archaeo-Environment (2010). The mill was subsequently identified as one of the key sites forming part of the HLF-funded Coniston Copper project, run by the LDNPA. As part of the project, NAA were commissioned in 2016 to undertake a detailed archaeological survey of the site, working together with local volunteers and JPAH (NAA 2016).
- 3.7 The 2016 community survey provided useful information on the operation of the mill and allowed an interpretive model to be developed for the site as a whole. However, it also raised a series of unresolved questions, most notably in relation to the layout and operation of the crusher and jig houses, and the location of a second water wheel listed in the 1875 sales inventory. The 2017 evaluation was designed to further explore—and hopefully answer—these questions.

## **4.0 AIMS AND OBJECTIVES**

4.1 The aims, objectives and methodology for the present work were:

- to provide training in archaeological methods and techniques to local volunteers and to equip them with new skills;
- to determine the condition of any structural remains and associated archaeological deposits;
- to define and identify the nature of specific archaeological deposits on site and to interpret these in relation to a series of research questions arising from the 2016; and
- to prepare an illustrated report on the results of the evaluation for submission to LDNPA and for distribution to the wider public as part of the Coniston Copper project. Copies of this report will be deposited with the LDNPA Historic Environment Record (HER).

4.2 The site code was PRE17.

## **5.0 METHODOLOGY**

### **Evaluation**

5.1 All three evaluation trenches were excavated by hand. Because of the high quality of the structural remains in Trench 1, the excavation was only taken to the surface of the principal paved surface. Similarly, in Trench 2 the excavation was taken down to the surface of a well-preserved cobbled surface, although a small sondage allowed examination of some of the sub-floor deposits. Trench 3 was excavated to the top of a natural clay surface. Volunteers were encouraged to participate in all aspects of the excavation and recording.

5.2 Archaeological deposits were cleaned by hand and all identified features were planned and photographed. Written descriptions of all archaeological features and deposits were recorded on pro forma sheets using the NAA context recording system. All site records were checked, cross-referenced and computerised following completion of fieldwork. Harris matrices were constructed for all trenches.

- 5.3 Drawn records of all archaeological features were produced at a scale of 1:10 for sections and elevations, and 1:20 for plans. A planning grid was surveyed in to the Ordnance Survey National Grid. Information was transferred to AutoCAD software and reproduced for incorporation within this report. All levels were tied in to Ordnance Datum.
- 5.4 A photographic record of the site was taken using a digital camera at a resolution of above 10 megapixels. All photographs contained a graduated photographic scale of appropriate dimensions, north arrow and board with details of context and site code. A full photographic record will be submitted with the site archive.
- 5.5 Pottery, animal bone and other categories of artefacts were collected as bulk samples. Finds were appropriately recorded and processed using the NAA system and submitted for post-excavation assessment.
- 5.6 Palaeoenvironmental samples were taken from appropriate deposits. These were processed by NAA and submitted to Kamal Badreshany at the Durham Archaeomaterials Research Centre (DARC Lab) for specialist mineral assessment in order to inform a greater understanding of what stages of the dressing processes were being conducted in key areas of the site. Recovery and sampling of environmental remains was carried out in accordance with published guidelines (Campbell *et al.* 2011; Historic England 2015).



*Plate 2: view of the crusher house and Trench 1 from the east. (Image courtesy of Mike Mitchell).*

## 6.0 RESULTS

### Trench 1

- 6.1 Trench 1, measuring 3m x 6m, was located within the crusher house and aligned to correspond with the centre of the water wheel (Fig. 3; Plate 2). It was anticipated that a trench in this position might provide information on the layout and function of some of the machinery that transferred power from the water wheel's axle to the crusher.
- 6.2 The earliest deposit uncovered was a substantial flagstone floor composed of rectangular or near-rectangular slabs of Borrowdale Volcanic rock (Plate 3). This was recorded as three contiguous flagstone surfaces (**008**, **009** and **010**) because of variations in construction, but the whole floor appears to have been built as part of a single-phase (Plate 3).
- 6.3 Surface **008** abutted the north-facing wall of the crusher house and was demarcated to the north by a horizontal timber (**007**) (Fig. 3). Compared to other parts of the floor, the slabs forming surface **008** were less regular and of a smaller size (generally between 0.06m x 0.45m and 0.45m x 0.55m).



*Plate 3: Trench 1 from the west with a clear view of flagstone surface 008–010.*

- 6.4 Surface **009** was in the central section of the trench and covered an area of approximately 3m x 3.6m (Fig. 3). It was demarcated to the south by timber **007** and to the north by a narrow, rectangular gap. The flagstones forming **009** were comparatively large (up to 0.6m x 1.7m), set close to one another and laid on an east-west alignment.
- 6.5 Surface **010** abutted the south-facing wall of the building and comprised large flags of a similar size to those forming **009** but laid further apart and at a slightly lower level.
- 6.6 The flagstone surface **008–010** contained or incorporated a number of features, of which the most significant were a group of three rectangular postholes aligned north-south across the centre of the trench (**011**, **012** and **013**). Posthole **011** was located 0.80m north of the building's south wall and measured approximately 0.2m x 0.2m by 0.5m deep (Plate 4). At the base was a fragment of horizontally laid saturated wood above a stone slab. It was filled with a grey-brown silty clay with occasional small stones towards the top (**003**); there was no evidence for wood above the basal timber and it can be assumed that any vertical post was removed before the infill process began.



*Plates 4 and 5: posthole 010 after removal of fill 003 (left), and posthole 012 after removal of fill 004 (right).*

- 6.7 Posthole **012** was located 1.70m north of **011**, in the centre of the trench. It measured 0.22m x 0.24m by 0.5m deep and, like posthole **011**, contained the remains of a timber plank at its base, resting on a stone slab (Plate 5). The lower 0.30m of the fill in the posthole comprised rotten timber with a series of voids above. The top section comprised small stones and iron fragments resting on what appeared to be horizontally set slate fragments (**004**). The presence of deliberately set slate in the

upper fill of **012** suggests that this posthole might have been reused after the original timber upright was removed or—less likely—had rotted.



*Plate 6: posthole **013** after removal of fill **005**, with void for braced timber to left.*

- 6.8 The third posthole (**013**) was very similar to the other two, measuring 0.24m x 0.26m by 0.5m deep, and also had the remains of a basal timber resting on a stone slab (Plate 6). Posthole **013** was over-dug, and this revealed the fragmentary remains of two pieces of angled wood, presumably braces associated with the basal timber and the putative vertical post.
- 6.9 The fill of the posthole followed a similar sequence to that observed in **012**. The top section comprised a fill of clay, stone and iron fragments above a series of voids with wood towards the base. As with **012**, this might indicate the posthole was reused after the original timber upright was removed or that the post had rotted in situ.
- 6.10 Dividing surface **008** and **009** was a horizontal timber (**007**; Plate 7), which had been set into a deliberate gap between the flagstones. The eastern end of the timber coincided with the northern side of posthole **011**, and to the west continued beyond the edge of the evaluation trench. It measured 0.16m wide by 1.5m long and had a slot or vertical depression running along its length, probably the result of decay rather than a deliberate feature.



*Plate 7: timber 007.*

- 6.11 One of the surface flags surrounding posthole **012** had a rectangular notch cut into one corner, presumably to accommodate a timber upright. The top of another potential rectangular posthole (**006**) was observed immediately east of **012** and close to the edge of the trench, but on excavation this proved to be a sunken area where a flag stone had previously been removed. A similar hollow lay to the north. A small sondage dug in this location revealed a packing layer of clay and gravel set below the flag stones.
- 6.12 There were other fragments of wood around posthole **011** and on the surface of **008**, but none of these were in situ nor did they appear to be associated with timber **007**. West of posthole **013** was a rectangular gap between flagged surfaces **009** and **010**. This gap is of a similar size to the slot for **007** and could have held a similar timber feature.
- 6.13 The remains of iron bolts were recorded on a number of the flag stones. In particular, there were concentrations on surface **009** west and south of the central posthole **012** and a second group in the north-western part of the trench close to the building's south-facing wall. The bolts are likely to have used to secure or reinforce timbers and appear to have been cut down to the surface of the flagstones during the removal of equipment from the building.

- 6.14 The flagstone surface was covered by a dark grey silty clay (**002**) that contained a concentration of tumbled building stone against the north-facing wall of the building and a spread of smaller stone in the north-western corner of the trench (Fig. 4). This contained a number of bottle glass fragments plus iron nails, bolts and other ferrous fragments. Above this was a grey, silty clay topsoil (**001**).

### **Trench 2**

- 6.15 Trench 2, measuring 3m x 6m and aligned east-west, was located in the central area of the building, which was identified during the 2016 survey as the probable jig house (Fig. 5). The trench lay between two high-level chutes or hoppers on the building's east-facing wall and it was hoped that excavation might provide information relating to the position and type of any equipment used within the building.
- 6.16 The earliest deposit exposed was a well-preserved cobbled surface (**103**) that extended across the whole of the trench (Plate 8). To the west the cobbles ran beneath a low stone plinth built against the base of the building's east-facing wall. The plinth was recorded as feature **503** during the 2016 survey and interpreted then as the support for a wooden box drain or launder (NAA 2016, 59).



*Plate 8: Trench 2 from the west, showing the cobbled surface.*

- 6.17 The cobbles formed a uniformly level surface set in a matrix of soil, gravel and clay. The cobbles were water-rolled volcanic rock, suggesting they were sourced from one of the local becks. Most were laid with flat-face uppermost although some, particularly in the south-east sector of the trench, were set on edge. There was no discernible pattern or change across the surface of **103**, although the cobbles tended to be larger and set further apart in the northern and western sectors of the trench.
- 6.18 The only possible feature recorded within **103** was an irregular, sub-square hollow (**104**; Plate 9), measuring 0.27m x 0.30m by 0.16m deep (Plate 9). This was filled with a dark brown soil (**105**) containing some fragments of roofing slate. The sides and base of **104** were very irregular, and it could not be ascertained if this was a deliberate posthole or an area where cobbles had been removed or destroyed.



*Plate 9: feature **104**; a possible posthole.*

- 6.19 A 1m x 1m by 0.35m deep sondage was excavated at the east end of the trench to investigate the sequence of construction beneath the cobbled surface **103** (Plate 10). This indicated that the cobbles had been laid on a layer of grey soil and stone (**106**) that sloped steeply down to the east. Below this, two further sloping deposits of brown soil and sand (**107**) and grey clay and soil (**108**) were observed. Layers **106–108** appear to be a series of dump deposits, presumably laid down as a level sub-surface

for cobbled floor **103** during the construction of the terrace. There was no evidence of an earlier construction or activity phase observed within the sondage.



*Plate 10: Trench 2 sondage, view from north.*



*Plate 11: ore processing waste (101) above cobbled surface.*

- 6.20 In the south-west corner of the trench the cobble surface was overlain by a thin laminated deposit of very fine sand and gravel (**102**), which was sealed by a 0.04m thick layer of fine brown gravel with quartz (**101**). Deposits **101** and **102** had the appearance of sand and gravel waste from mineral processing operations (Plate 11).
- 6.21 Elsewhere in the trench, surface **103** was generally sealed by top soil (**100**), which also lay above **101** and **102**. This was a black, loam-rich deposit, approximately 0.10m thick, that contained large (>0.20m long) fragments of slate and occasional stone blocks.
- 6.22 Scattered across the surface of the trench at ground level were a number of large pieces of tumbled masonry, some of which had been used relatively recently to form the surrounds for small, temporary camp fires.

### **Trench 3**

- 6.23 Trench 3 measured 1m x 2m and was located roughly parallel with and 2m north of the north-facing wall of the crusher house wheel pit (Fig. 6; Plate 12). This area had been identified during the 2016 survey as the location of a possible working platform or timber structure (NAA 2016, 49). The trench was opened on the morning of the last working day and only the southern end was fully excavated.



*Plate 12: Trench 3, view from north.*

- 6.24 The earliest deposit exposed was a clay surface, probably a natural hill wash deposit, which was observed in the eastern section of the trench at a depth of 0.25m. Above this, and extending the full length of the trench, was a layer of grey clay (205), possibly a natural subsoil. This had a maximum depth towards the centre of the excavation of approximately 0.20m.
- 6.25 To the east, deposit 205 was sealed by a sequence of comparatively thin (0.6m–0.8m thick) mineral-stained gravel layers (202–204) that sloped to the east. To the west, deposit 205 was overlain by a 0.10m thick layer of brown soil with small stones and gravel (206). The relationship between 206 and layers 202, 203 and 204 could not be established.
- 6.26 No features or other forms of structural evidence were observed within Trench 3.

## **7.0 SPECIALIST FINDS ASSESSMENT**

- 7.1 Finds recovered during the excavation were submitted for specialist assessment and the full assessment reports can be found in Appendices B to D. What follows below is a summary of these findings.

### **Pottery (Charlotte Britton)**

- 7.2 Fifteen sherds of post-medieval pottery were submitted for assessment, all of which dated to between the 18th and 19th century. These were classified as domestic ware and were British in origin. Although the exact source is unknown, they were most likely produced locally. Table wares were exclusively represented, and both the wares and forms identified were highly characteristic of the period. The majority of the material recovered was excavated from topsoil or unstratified contexts; therefore, it provides little information about the features on site. The estimated total number of vessels recovered was three.

### **Building Materials (Chrystal Antink)**

- 7.3 Six fragments of building material were recovered during the 2017 excavation at Penny Rigg copper mill. One fragment, from context 100 (topsoil), is clearly a slate roof tile. Slate was a common roofing material in slate-rich districts from at least the 18th century (New Forest NPA 2013), and Penny Rigg has abundant naturally occurring slate available to it.

7.4 The remainder of the stone is also slate but has no obvious use marks. None of this stone was being utilized structurally where it was recovered and, as this variety of stone is so abundant, it is impossible to say how it was used, if it was used at all.

#### **Small finds (Elizabeth Foulds)**

7.5 In total, 148 finds were submitted for assessment. The majority of iron finds consisted of nails and bolts, and other structural remains.

7.6 Most finds came from the topsoil (001) and subsoil (002) in the crusher house, including a variety of nails, bolts, iron strips and amorphous iron concretions. Fragments of post-medieval glass vessels were also found in these contexts, including a broken codd bottle.

7.7 A small number of finds came from features located in the crusher house. A number of long iron nails or spikes with fragments of wood adhering to the corrosion, an end fragment of a bolt with a square nut lodged in an L-shaped bracket, and numerous iron concretions of unknown origin came from the series of three rectangular postholes set amongst the flagstone surface.

7.8 Finds from Trench 2, located in the building of the probable jig house, were limited to only the Topsoil (100) and mineral dressing waste (102) contexts. Artefacts primarily included nails, but there was a cast iron beehive-shaped fitting (Fig. 7), which probably originated from a piece of machinery.

7.9 The majority of the finds from both features and top/subsoil were from structural rather than industrial contexts, or machinery. The only recognisable possible remnant of a piece of machinery was the beehive-shaped object from the jig house. The glass was primarily 19th–20th century in date, probably reflecting the consumption of food by people working at the mill.

## **8.0 DISCUSSION**

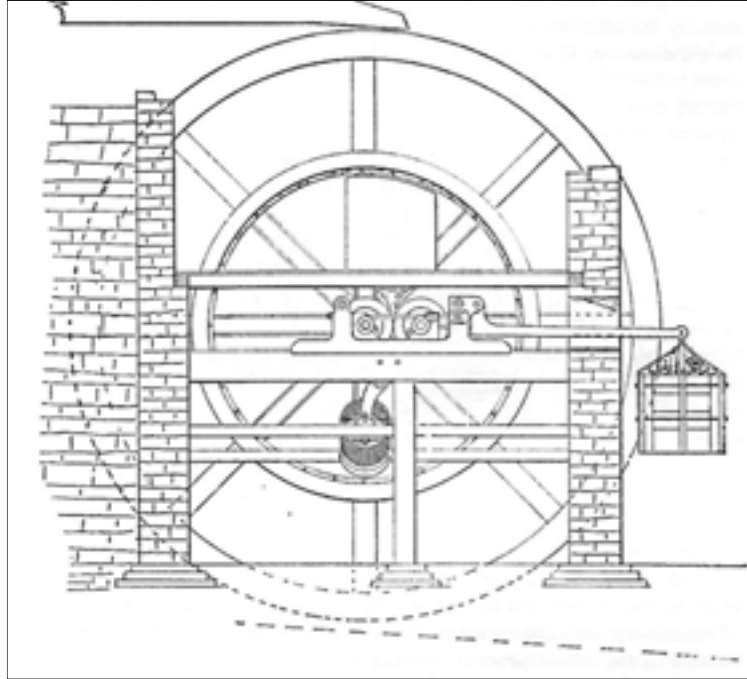
### **Trench 1**

8.1 The evaluation trench within the crusher house revealed a well-preserved flagstone surface associated with a series of large postholes and a sub-surface timber framework. The presence of postholes was not unexpected, as the 2016 survey had found evidence for a complex timber construction within the crusher house. A series

of joist holes on the building's west wall and a corresponding timber recess on the interior of the gable wall were interpreted as evidence for an eaves-level floor, which was supported to the east and north by braced timber uprights that may have also carried a putative timber-built north gable (NAA 2016, 53). The lower level joist holes on the north and east-facing walls were further interpreted as evidence for a possible timber partition or mezzanine platform at the southern part of the building, possibly associated with support for the crushing rollers and the extended arm of the water wheel (NAA 2016, 5).

- 8.2 All three of the square postholes excavated during the evaluation (**011**, **012** and **013**) in the centre of the trench were of identical size and depth and must have held large, square-cut load-bearing timbers. The discovery that the timber in posthole **013**—and by implication those in postholes **011** and **012**—was part of a much larger wooden substructure with angled braces and footings suggests that the uprights were intended to carry a substantial weight. In addition, the deposition of a 0.50m deep layer of packing material between the base of the substructure and the flagstone surface would have provided extra support for the uprights, and also helped to absorb and spread the impact of any working machinery housed above. Such a complex arrangement is unlikely to have been needed just to support a wooden floor and it is more likely that this structure was part of the support mechanism for the heavy cast iron crushing rollers.
- 8.3 There are a number of contemporary technical drawings of crushing mills and most of these show the rollers supported on a framework of massive timbers. Westgarth Forster (1883, plate 7) depicts a crushing mill that operated on Alston Moor, Cumbria, in the 1820s and the rollers—in this instance a set of three—are supported on large horizontal timbers set into opposing walls and joined by vertical posts; these posts also support a high-level floor. Davies (1902) illustrates a slightly simpler arrangement, in which the crushing rolls are set on massive horizontal timber beams bedded into opposing walls and supported in the centre by a single upright. Slighter timbers, again bedded into opposing walls, support a high-level floor and a trommel. Davies' illustration does not show any sub-floor support structure, but the central upright is depicted with a below-ground pad (Plate 13). A similar arrangement with a central timber support is shown in Phillips and Darlington (1857, 119).
- 8.4 Although crushing rollers survive at a number of mining sites—for instance, at Greenside Mine, Cumbria—it is unusual for the timber support to also survive. A rare

example is at Killhope lead mine in Weardale, County Durham, where much of the wooden framework for a set of single rollers is still in place in an open area between the water wheel and the associated jig house. At Killhope, a free-standing timber support structure sits on a base framework of edge-set beams that are secured with iron bolts to a flagstone surface (Plate 14). There is no suggestion of a sub-floor structure at Killhope.



*Plate 13: ore crusher (after Davies 1902).*



*Plate 14: ore crusher supports at Killhope mine, Co. Durham.*

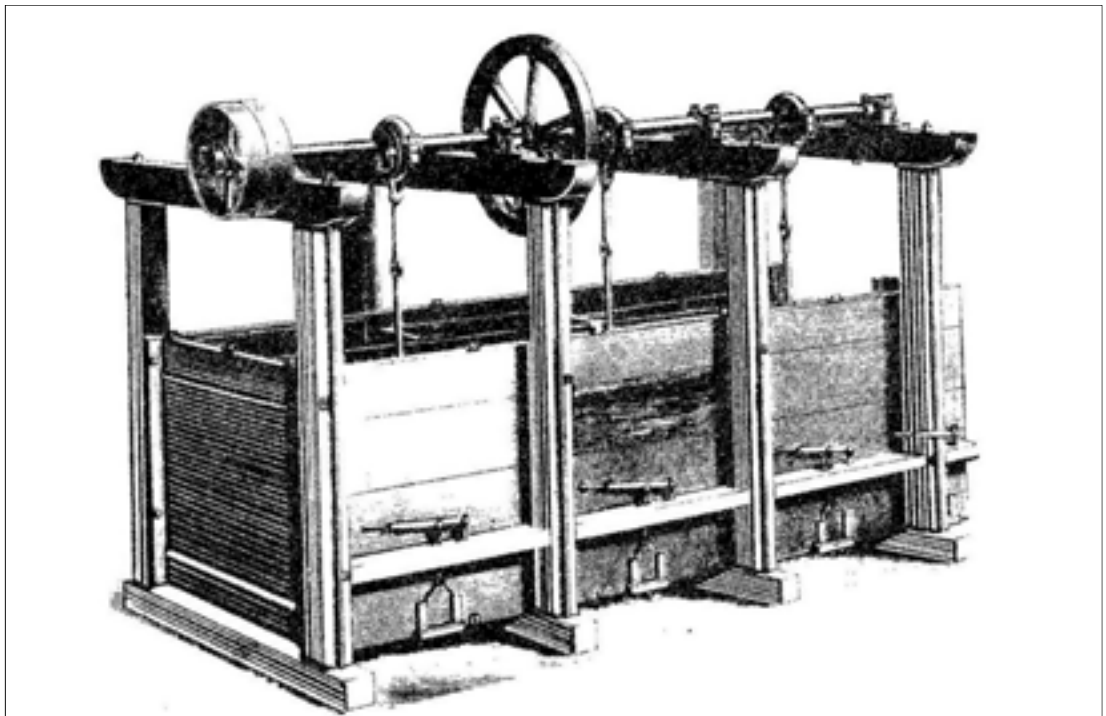
- 8.5 The other features in Trench 1 are harder to interpret. The slight linear depression formed by surface **010** might relate to the position of the raff wheel, the elevator wheel that returned oversized material from the trommel to the first floor for re-crushing. The raff wheel was attached to the extended water wheel axle, and so is likely to have been located close to the wheel pit wall but, with the exception of the cut bolt shanks in the north-west part of the trench, there are no features that can be associated directly with the position or operation of the raff wheel.
- 8.6 The long, horizontal timber (**007**) set between the flagstone west of posthole **110**, could be interpreted as the footing or base plate for a wooden partition attached to the crusher support framework and intended to control the spread of waste from the rollers and trommel. The linear gap between flagged surfaces **009** and **010** may represent the footing of a similar partition on the north side of the crusher framework. Whether this interpretation is correct or not, it is worth observing that the flagstone surface itself was remarkably clean, which suggests that as much waste as possible was being collected for further processing and concentration elsewhere at the mill.

## **Trench 2**

- 8.7 The evaluation trench within the putative jig house was located to provide information on the building's function. The trench exposed a well-preserved cobbled surface (**103**) but no evidence—for example drains, machine bases or holding-down bolts—was found to indicate the position of any equipment within the structure. The only evidence for activity was a discrete deposit in the south-west corner of the trench of mineral-rich sand and gravel (**101** and **102**). This was probably waste from jiggling or a similar concentration process. However, soil analysis found no trace of copper ore in the sample from **101** that was submitted, although there were traces of barite and witherite (see Appendix E). A broken iron fitting found on the cobbled surface has been tentatively identified as part of an eccentric gear and support rod mechanism from what might have been a mechanical jig (cat. no. 43).
- 8.8 The absence of evidence for any machinery may be due to the location of the evaluation trench. This lay between the two ore hoppers in the building's west wall. It is possible that any processing equipment was located directly below the hoppers and so would have been outside the excavated area. However, this apparent lack of evidence may also reflect the type of equipment in use. Nineteenth-century illustrations of both hand-operated and mechanical jigs (Plate 15) show jig boxes either positioned directly on the floor or sitting on base timbers; there is no indication

of holding bolts or machine bases on these drawings, and it is likely that the weight of the jig box, especially when filled with ore and water, was such that no additional fixings or supports were required to hold it in place.

- 8.9 Some evidence might have been expected for drainage, especially between the jigs and the settling ponds north of the building. The 2016 survey interpreted plinth **503** at the base of the east-facing wall as the support for a narrow launder or wooden box drain. It is conceivable that raised angled launders ran from individual jigs to the drain on plinth **503**, which then fed jiggged material—the ore-rich ‘middlings’—to the ponds. The use of raised launders between the jigs and drain would leave no archaeological evidence.



*Plate 15: mechanical jigs (after Hunt 1887).*

- 8.10 The results of the evaluation suggest that the building was probably a jig house but have provided no further information about how the jigs were powered. Mechanical jigs were in common use by the 1860s, and it is more than likely that the Penny Rigg jigs were powered by a water wheel. There is no compelling evidence for a water wheel attached to the jig house and it is most likely that the jigs were powered through extended shafts and gearing by the crusher house water wheel. The second water wheel, which is listed on the 1875 sales inventory of the mill, remains elusive (NAA 2016, 56) but could well have been located on the lower terrace south-east of the jig house, where it operated buddles and a set of stamps. The absence of copper

from deposit **101** is puzzling. This deposit appeared to be typical of the sorts of fine sands and gravels produced during ore concentration, but somewhat surprisingly the only minerals detected in the sample were barite and witherite; further sampling in this area would therefore be an interesting exercise.

- 8.11 The results from Trench 3 were ambiguous. No features were found and the comparatively shallow layers of soil and gravel above the subsoil are best interpreted as the spread and accumulation of spoil from crushing and processing in the immediate area. However, Trench 3 was comparatively small, and the archaeological potential of this particular area remains essentially untested.
- 8.12 The evaluation has provided interesting evidence for a large and complex timber structure within the crusher house and confirmed that the other building was indeed a jig house. More importantly the evaluation has revealed, perhaps unexpectedly, the remarkable condition of the buried structural remains and the site's excellent potential for future archaeological work.

## REFERENCES

- Cameron, A. and Withey, L. (2017) *Ore Mining in the Lake District*. Stroud: Amberley Publishing.
- British Geological Society (BGS) (2018) *Geology Viewer*. [Online] Available at: <http://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/viewer.html> (accessed on 19/01/2018)
- Campbell, G., Moffett, L. & Straker, V. (2011) *Environmental Archaeology. A Guide to the Theory and Practice of Methods, from Sampling and Recovery to Post-Excavation (second edition)*. Swindon: English Heritage
- Chartered Institute for Archaeologists (CIfA) (2014) *Standard and guidance for archaeological field evaluation*. Reading: Chartered Institute for Archaeologists.
- Chartered Institute for Archaeologists (CIfA) (2014b) *Standard and guidance for archaeological excavation*. Reading: Chartered Institute for Archaeologists.
- Chartered Institute for Archaeologists (CIfA) (2014c) *Standard and guidance for the collection, documentation, conservation and research of archaeological materials*. Reading: Chartered Institute for Archaeologists.
- Davies, E. H. (1902) *Machinery for Metalliferous Mines: a practical treatise for mining engineers, metallurgists and managers of mines*. London: Crosby Lockwood and Son.
- English Heritage (2008) *MoRPHE Project Planning Note 3 Archaeological Excavations*. London: English Heritage.
- Historic England (2015) *Geoarchaeology: Using earth sciences to understand the archaeological record*. Swindon: Historic England.
- Hunt, R. (1887) *British mining: a treatise on the history, discovery, practical development and future prospects of metalliferous mines in the United Kingdom*. London: Crosby Lockwood and Son.
- Northern Archaeological Associates (NAA) (2016) *Penny Rigg Copper Mill: Archaeological Community Landscape and Building Survey*. Northern Archaeological Associates Report No. 16/145.

NAA (2018) *Tilberthwaite Mine: Archaeological Community Landscape and Building Survey*. Northern Archaeological Associates Report.

Phillips, J. A. and Darlington, J. (1857) *Records of Mining and Metallurgy: Or, Facts and Memoranda for the Use of the Mine Agent and Smelter*. New York: Spon.

Forster, W. (1883) *A Treatise on a Section of the Strata from Newcastle-upon-Tyne to Cross Fell*. Second Edition. Alston: John Pattison.

**APPENDIX A**  
**CONTEXT AND FINDS CATALOGUE**

<b>Context</b>	<b>Area</b>	<b>Trench</b>	<b>Interpretative description</b>	<b>Relationships</b>	<b>Notes</b>	<b>Finds and sample information</b>
001	Crusher House	1	Topsoil	Above subsoil 002		Glass bottle fragments, metal fragments, ceramic fragments
002	Crusher House	1	Subsoil	Under topsoil 001, above 008, 009 and 010		Glass bottle fragments, metal fragments, nails, bolts etc.
003	Crusher House	1	Fill of post hole 011			Metal bolt with remains of wooden planks still evident
004	Crusher House	1	Fill of post hole 012			Iron wedge, wood
005	Crusher House	1	Fill of post hole 013			Pot, metal
006	Crusher House	1	Sunken area	Filled by 002		
007	Crusher House	1	Timber	Under subsoil 002		
008	Crusher House	1	Flag stones	Under subsoil 002		
009	Crusher House	1	Flag stones	Under subsoil 002		
010	Crusher House	1	Flag stones	Under subsoil 002		
011	Crusher House	1	Cut of post hole	Filled by 003		
012	Crusher House	1	Cut of post hole	Filled by 004		
013	Crusher House	1	Cut of post hole	Filled by 005		
014	Crusher House	1	Ground make up / sub cobble layer	Under 008, 009 and 010		Wood
100	Mill	2	Topsoil	Above 101 and 103		
101	Mill	2	Processing waste	Under topsoil 100, above 102		
102	Mill	2	Mineral dressing waste	Under 101, above 103		
103	Mill	2	Area of cobbles	Under 100, 101 and 102		
104	Mill	2	Sub-square hollow / possible post hole	Filled by 105, above 103		
105	Mill	2	Fill of possible post hole 104			
106	Mill	2	Sub cobble layer	Under 103, above 107		
107	Mill	2	Sub cobble layer	Under 106, above 108		
108	Mill	2	Sub cobble layer	Under 107		
503	Mill	2	Plinth—context number reused from Penny Rigg Building & Landscape survey			

Context	Area	Trench	Interpretative description	Relationships	Notes	Finds and sample information
			project—project no. 1319			
201	N of Wheel pit	3	Topsoil	Above 202 and 206		
202	N of Wheel pit	3	Layer	Under topsoil 201, above 203		
203	N of Wheel pit	3	Layer	Under 202, above 204		
204	N of Wheel pit	3	Layer	Under 203, above 205		
205	N of Wheel pit	3	Layer	Under 204 and 206		
206	N of Wheel pit	3	Layer	Under topsoil 201, above 204		

**APPENDIX B**  
**POST-MEDIEVAL POTTERY**

*Charlotte Britton*

**INTRODUCTION**

A total of 15 sherds (90.8g) of pottery were recovered from the 2017 community excavations at Penny Rigg, Coniston. All the pottery recovered was organised by stratified deposit (context) and quantified by count and weight (Table 1). This report presents the results of the assessment of that material examined in accordance with *A Standard for Pottery Studies in Archaeology* (Barclay *et al.* 2016).

**Table 1: Pottery sherds by count and weight**

Context	Count	Weight (g)
000	3	5.4
001	2	10.7
005	3	17.7
100	7	57
Total	15	90.8

**METHOD**

All the material recovered was assessed by eye, and wares and chronology were identified (Table 2). Vessel form and decoration were also documented where practicable.

**RESULTS**

The assemblage dated to the post-medieval period (18th–19th century) and was classified as domestic ware, commenting on the nature of the site. All of the pottery present was British in origin, and although the exact source is unknown, it was most likely produced locally. Table wares were exclusively represented, and both the wares and forms identified were highly characteristic of the period. The wares present included; Brown glazed ware, Stoneware and Whiteware. Domestic forms identified were typical of this period, exclusively taking the form of hollowares, including jars and a possible tea pot lid. The majority of the material recovered was excavated from topsoil or unstratified contexts and therefore provides little information about the features on site. The estimated total number of vessels recovered within the 15 sherds was three, with each ware representing a single vessel. The eight sherds of Stoneware recovered from across three separate contexts (including unstratified material) for instance, belonged to a single jar.

**STATEMENT OF POTENTIAL AND RECOMMENDATIONS**

All the pottery recovered dated from 18th–19th century and is in very good condition, however, as it is highly characteristic of the period and region; no further study is required, and it is therefore recommended for discard.

## REFERENCES

Barclay, A., Knight, D., Booth, P., Evans, J., Brown, D. and Wood, I. (2016) *A Standard for Pottery Studies in Archaeology*. Prehistoric Ceramics Research Group, Study Group for Roman Pottery and Medieval Pottery Research Group.

**Table B2: Wares present in each context**

Context		000		001		005		100		Total Count	Total Weight (g)
Ware	Date	Count	Weight (g)	Count	Weight (g)	Count	Weight (g)	Count	Weight (g)		
Brown glazed ware	18th—19th century							5	41.3	5	41.3
Stoneware	Late 18th century	3	5.4	2	10.7	3	17.7			8	33.8
Whiteware	19th century							2	15.7	2	15.7
Total		3	5.4	2	10.7	3	17.7	7	57	15	90.8

**APPENDIX C**  
**BUILDING MATERIALS REPORT**

*Chrystal M L Antink*

**INTRODUCTION**

Six fragments of stone totalling 1,486g were recovered from the community excavation at Penny Rigg mill in Cumbria. One is clearly a roof slate, while the significance of the remainder is unclear.

**METHOD**

All fragments were counted and weighed and were recorded in a Microsoft Access database. Unusual features and signs of use were noted.

**RESULTS**

One fragment, from context **100** (topsoil) in the mill trench, is clearly a slate roof tile. Its broken dimensions are 145mm x 104mm x 13mm, and has a pecked hole approximately 7mm x 5mm, weighing 313g. Slate has been a common roofing material in slate-rich districts since at least the 18th century (New Forest NPA 2013), and Penny Rigg has abundant naturally occurring slate available to it.

The remainder of the stone, from the Crusher House trench, is also slate but has no obvious use marks. Four non-adjointing fragments weighing 220g came from context **002**, the subsoil; the last fragment, 953g, was from the fill of post hole **013**. None of this stone was being utilized structurally where it was recovered, and as this variety of stone is so abundant it is impossible to say how it was used, if it was used at all.

**STATEMENT OF POTENTIAL AND RECOMMENDATIONS**

Only the roof tile was of archaeological significance, and it was recovered from topsoil, as opposed to significant stratigraphy; the remainder of the stone was indistinguishable from the surrounding natural stone. As such, none of the material is recommended for retention.

**REFERENCES**

New Forest National Park Authority (2013) *Tile and Slate Roofing* [Online] Available at [http://www.newforestnpa.gov.uk/download/downloads/id/851/tile\\_and\\_slate\\_roofing](http://www.newforestnpa.gov.uk/download/downloads/id/851/tile_and_slate_roofing) (accessed on 10/11/2017)

**APPENDIX D**  
**FINDS ASSESSMENT REPORT**

*Elizabeth M. Foulds*

**INTRODUCTION**

This report discusses the finds recovered from the trenches excavated at Penny Rigg Copper Mill, Coniston, Cumbria, in April 2017 (NY 30656 00695). The majority of the finds consist of structural remains related to the crusher house and post-medieval glass bottles.

**METHOD**

Finds were recorded on 13 February 2018 in a Microsoft Access database. The specialist finds recording and reporting was completed in accordance with the national finds standards and find type specific guidance (English Heritage 2008, ClfA 2014) where possible.

A list of data fields used during the recording process as appropriate is given in Table D1. This file is available with the site archive.

A catalogue of finds is available at the end of this report and is in order by trench and context number.

*Table D1: description of data fields used to record general finds in 'Finds Database'.*

Field	Data Type	Description
ID	Number	Unique identifying number
Project	Number	NAA project number
Site_Code	Text	NAA site code
Area	Text	NAA site area designation
RF_no	Number	NAA recorded find number
Context	Number	Context number
Material	Text	Material type
ObjectType	Text	Simple object description if relevant
Cat_Description	Text	Full description of the find, text used in finds catalogue.
Cat_Dimensions	Text	Full measurements of the find, text used in finds catalogue.
Cat_Period	Text	Period category of the find, text used in finds catalogue
Count	Number	Full count of finds the record refers to
Weight	Number	Weight of find in grams
KeepDiscard	Text	Indicates if the find should be kept for archive or discarded
Xray	Text	X-ray number where relevant
ConservRecommended	Text	Indicates whether a find should be conserved either for further analysis to make it stable for archive
NeedsIllustration	Yes/No	Indicates finds that should be illustrated for the report
NeedsPhotograph	Yes/No	Indicates finds that should be photographed for the report

**RESULTS**

In total, 148 finds were submitted for assessment (Table D2). The majority of iron finds consisted of nails and bolts, and other structural remains.

## Trench 1

Most finds came from the topsoil (001) and subsoil (002) in the crusher house, including a variety of nails, bolts, iron strips and amorphous iron concretions. Fragments of post-medieval glass vessels were also found in these contexts, including a broken codd bottle.

A small number of finds came from features located in the crusher house. From the series of three rectangular postholes set amongst the flagstone surface came a number of long iron nails or spikes with fragments of wood adhering to the corrosion, an end fragment of a bolt with a square nut lodged in an L-shaped bracket, and numerous iron concretions of unknown origin.

*Table D2: summary of finds by material and trench.*

	Trench 1	Trench 2	Total
Iron	112	30	142
Glass	5	1	6
<b>Total</b>	<b>117</b>	<b>31</b>	<b>148</b>

## Trench 2

Finds from Trench 2, located in the building of the probable jig house, were limited to only the Topsoil (100) and mineral dressing waste (102) contexts. Artefacts primarily included nails, but there was a cast iron beehive-shaped fitting (Fig. 7), which may have been one of the eccentric gears on the drive shaft of a jig; the fitting would have connected with a rod attached to one of the sieve boxes (see Plate 15 for a contemporary illustration showing a jig with an eccentric fitting).

## DISCUSSION

The majority of the finds from both features and top/subsoil were from structural rather than industrial or machinery. The only recognisable possible remnant of a piece of machinery was the beehive-shaped iron object from the probable jig house, which may have been a fitting from a mechanised jig. The glass was primarily 19th to 20th century in date, probably reflecting the consumption of food by people working at the mill.

## RECOMMENDATIONS

Two finds are recommended for illustration in the report: the beehive-shaped fitting from Context 100 in Trench 2 and the L-shaped bracket with bolt and nut from Context 003 Trench 1.

The majority of the finds from the site are primarily structural in nature and do not add to our understanding of the site. Discard of finds should be completed through discussion with the local archive repository.

## REFERENCES

Chartered Institute for Archaeologists (CIfA) (2014) *Standard and guidance for the collection, documentation, conservation and research of archaeological materials*. Reading: Chartered Institute for Archaeologists.

English Heritage (2008) *MoRPHE Project Planning Note 3: Archaeological Excavations*. London: English Heritage.

## CATALOGUE

L: length, W: width, H: height, D: diameter

Measurements of iron finds taken directly from object.

### Trench 1

#### *Context 001: Topsoil*

1. **Glass bottle.** Clear bottle with plastic stopper intact. Letters embossed on the sidewall: 'AOMSO....ANCAST....&BARROW' and 'ULVERSTON & KENDAL'. One sherd has 'BARR' embossed on. Base has 'A DANDY - LION REC' embossed on it. 20th century.
2. **Glass bottle.** Transparent light blue/green glass bottle with letters embossed on the sidewall: 'T.B' '&' and 'RO'. May be the same as the codd bottle from Trench 1 Context 002. 19th century.
3. **Glass marble.** Translucent glass marble with mould seams, possibly from the codd bottle in Trench 1 Context 002. D: 18mm. 8.5g. 19th - 20th century.
4. **Iron bolt.** Heavy, square-shanked bolt (incomplete). L: 173mm, shank: 13mmx13mm, head or nut: 30mmx 25mm. 126g.
5. **Iron bolt with nut.** Incomplete bolt with square nut and washers/spacers. L: 76mm, shank: 10mmx9mm, head D: 18mm, nut (square): 21mmx 21mm, washer D: 25mm. 66g.
6. **Iron concretion.** Concretions of iron, lead and stone, possibly including an iron bar and nail. 686g.
7. **Iron nails.** Assortment of nails of varying lengths. Not all complete. 22g.
8. **Iron plate.** L: 170mm, W: 47mm, D: 6mm. 195g.
9. **Iron plate.** Iron plate with remnants of rivet remaining. L: 98mm, W: 54mm, D: 4mm. 71g.
10. **Iron plate.** Square iron plate with sub-rectangular hole in the middle. Plate L: 79mm x 85mm, D: 8mm, hole 24mm x 29mm. 237g.
11. **Iron strip.** L: 85mm, W: 27mm, D: 7mm. 69g.
12. **Iron sheet.** Thin sheet of iron with no remaining edges. L: 143mm, W: 62mm, D: 2mm. 38g.
13. **Iron wedge?** Iron bar, square shanked narrowing to rectangular shanked. L: 122m, top width: 24mm x 26mm, bottom width(incomplete): 23mm x 13mm. 329g.

14. **Iron & wood concretion.** Concretions of iron, wood and stone including a possible nail. 121g.

*Context 002: Subsoil*

15. **Glass bottle.** Four sherds of a translucent light blue/green codd bottle neck. Smaller sherds have letters embossed on them: 'AR BE'. May join sherds in Trench 1 Context 001. 19th century.
16. **Glass vessel.** Three clear translucent glass vessel sherds. Possibly from the same vessel in Trench 2 Context 100. Modern.
17. **Iron bolt.** Near complete bolt with visible threads and rounded head. L: 124mm, shank D: 12mm, head D: 30mm. 103g.
18. **Iron bolt and nut.** Bolt shank, threads still visible, with nut concreted on. shank L: 47mm, D: 16mm, nut: 27x27mm, H: 14mm. 91g.
19. **Iron bolt and nut.** Bolt shank fragment with square nut. L: 23mm, shank D: 9mm, nut: 22x22mm, H:13mm. 33g.
20. **Iron concretion mass.** Four iron concretion masses. 1756g.
21. **Iron nail.** Large nail. L: 103mm, head D (with concretion) 18mm. 53g.
22. **Iron nails.** All similarly sized, rectangular-shanked, flat round-headed nails. Most complete: L: 80mm, head D: 18mm, shank: 7mm x 6mm. 187g.
23. **Iron nail.** Small, nearly complete nail, square shank narrowing to rectangular, ?square head. L: 52mm, shank: 6x6mm, head: 13x14mm. 8g.
24. **Iron nail.** Three large nails and one similarly sized shank; square shanks narrowing to rectangular, ?square heads. Most complete: L: 107mm, shank: 9mm, head: 24x22mm. 100g.
25. **Iron.** Broadly wedge-shaped iron object. L: 78mm, W: 31mm, D: 33mm. 194g.
26. **Iron plate.** Iron square plate with circular central hole. Plate: 53mm x 54mm, D:5mm, Hole: 14mm D. 61g.
27. **Iron plate.** Half of what was probable a square iron plate with round hole in centre, now broken across the perforation hole. Complete W: 57mm, D: 6mm, Hole D: 16mm. 68g.
28. **Iron plate.** Iron plate fragment. L: 70mm, W: 54mm, D: 10mm. 139g.
29. **Iron spike.** Incomplete spike, square shank, square head. L: 215mm, shank: 15x15mm, head: 27x30mm. 303g.
30. **Iron strip.** Iron strip fragment. L: 93mm, W: 37mm, D: 9mm. 122g.

***Context 003: Fill of posthole 011***

31. **Iron concretion.** Iron concretions with wood and stone inclusions. 106g.
32. **Iron nail?** Possible large nail under significant concretion with only square shank visible. Shank 6x6mm. 70g.
33. **Iron bolt, nut and plate.** L-shaped bracket or other fitting with the end of a bolt with threads and square nut attached through a perforation hole. Wood adhering to iron corrosion. Shank L: 70mm, D: 13mm, nut: 28x29mm, H: 17mm. Plate: W:54mm. 199g.
34. **Iron spike.** Iron spike with square head and shank with fragments of adhering wood. L: 138mm, shank: 15x15mm, head: 31x32mm. 218g.
35. **Iron spike.** Iron spike with adhering wood. Largest fragment: L: 92mm, W: 68mm, D: 29mm. 103g.
36. **Iron spike?** Long iron object with fragments of adhering wood. L: 210, W: 65mm, D: 38mm. 361g.

***Context 004: Fill of posthole 012***

37. **Iron concretions.** Three large iron concretions. 1289g.

***Context 005: Fill of posthole 013***

38. **Iron concretion.** Six iron concretions, one with copper staining. 1132g.

***Context 006: Sunken area***

39. **Iron concretion.** 10g.
40. **Iron nail?** Probable incomplete large nail, only square shank visible under heavy concretion. L: 119mm, shank: 9x9mm. 66g.

**Trench 2**

***Context 100: Topsoil***

41. **Glass vessel.** Single colourless translucent glass vessel sherd of similar type to those in Trench 1 Context 002. Modern.
42. **Iron concretion.** Three iron concretion fragments. 67g.
43. **Iron fitting.** Incomplete cast iron beehive-shaped fitting, possibly broken. Circular fragment: largest D: 63mm, hole D: 22mm, H: 34mm. 646g. Figure 7.
44. **Iron nails.** Eighteen small square sectioned nails and nail fragments (no complete heads). Most complete: L: 40mm, shank: 4x4mm. 74g.
45. **Iron nail.** Large square sectioned nails with incomplete heads. Most complete: L: 89mm, shank: 8mm x 8mm. 111g.

46. **Iron plate.** Incomplete chamfered-edged plate with circular centrally placed perforation. The plate was broken diagonally across the perforation. L: 80mm, W: 46mm, D: 14mm, hole D: 10mm. 155g.
47. **Iron staple?** Small U-shaped iron bar with unclear profile. L: 22mm, W: 18mm, D: 5mm. 2g.

*Context 102: Mineral dressing waste*

48. **Iron concretion.** 14g.

*Context none*

49. **Iron and stone.** Two large stones (sandstone and slate) with iron fragments concreted on, mostly nondescript with one possible nail. 1138g.

**APPENDIX E**  
**XRF AND SEM SOIL ANALYSIS**

*Dr Kamal Badreshany*

**INTRODUCTION**

A sample of soil (PRE17) from a building associated with the Coniston Copper Mine was analysed using a portable X-ray Fluorescence spectrometer (pXRF) and a Scanning Electron Microscope fitted with an Energy Dispersive Fluorescence spectrometer (SEM-EDS) to determine the amount and nature of its copper content. The aim was to investigate whether the soil composition could identify the building as relating to processing from the nearby mine.

**BULK CHEMICAL ANALYSIS USING PXRF AND SEM-EDS**

**Analytical Methods**

The analytical work was undertaken at the Durham Archaeomaterials Research Centre (DARC) using a Bruker Tracer 5i and a Hitachi SEM-EDS. A bulk soil sample was dried and passed through a 2mm sieve to remove any large stones. The coarser fraction was saved for a separate investigation for evidence of copper.

The soil and the coarse fraction were examined in a Hitachi TM3000 SEM fitted with a SwiftED3000 EDS (Fig. 8). The soil was not homogenised at this stage, so discrete copper bodies and minerals could be assessed if found. In total, 1.5g of soil and 1g of coarse fraction were analysed. The accelerating voltage of the SEM was set to 15kV and the probe current was set to 700pA. The samples were investigated in Back-scattered Electron (BSE) mode. The bulk compositional analysis was generated by the SwiftED software using standardless matrix corrections and is semi-quantitative. The results can be found in Figure 9 and Table E1.

Two grams of soil was then powdered for 10 minutes using an agate ball mill and placed in a sample cup for bulk elemental analysis. Tracer 5i alloy calibrations for Geoexploration were utilised for the majors, minors, and trace elements. The pXRF fixed conditions for these calibrations were set at 45kV and 10  $\mu$  A using a 1 mil<sup>1</sup> Ti/12 mil Al filter for the trace elements 15Kv with no filter for the major elements. The results of the analyses can be found in the Table E2.

*Table E1: List of elements from the energy dispersive x-ray spectrometry analysis (EDS) of the mineral grain in Figure 8, showing a high barium content.*

Element	Weight %	Weight % $\sigma$	Atomic %
Carbon	8.951	1.766	19.578
Oxygen	36.077	0.919	59.239
Silicon	2.110	0.154	1.973
Sulphur	8.396	0.284	6.879
Potassium	0.489	0.113	0.328
Iron	11.425	0.487	5.374
Bromine	2.922	0.287	0.961
Barium	29.630	0.818	5.668

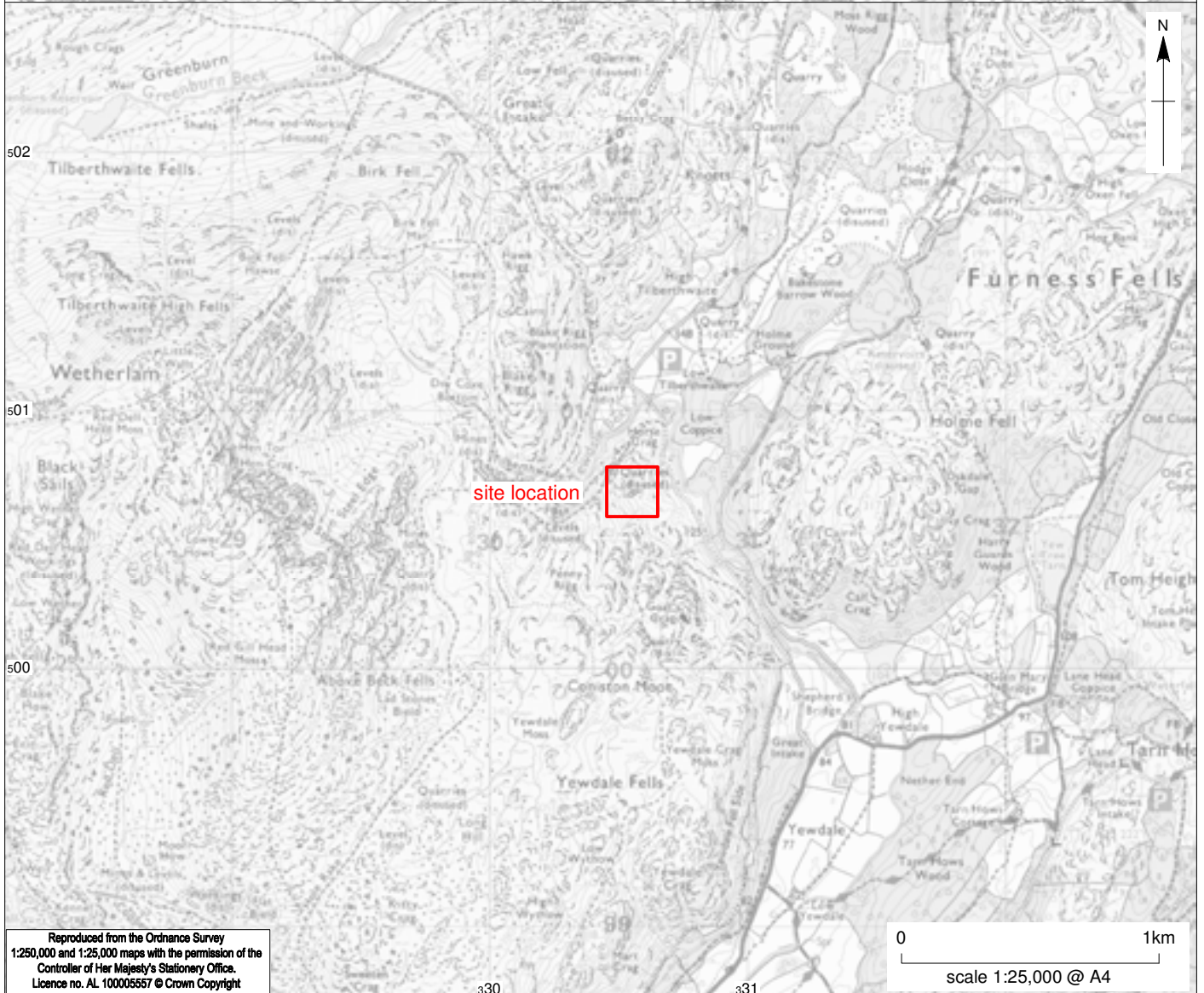
<sup>1</sup> One mil is 1/1000 of an inch and equals 0.0254mm.

## Results

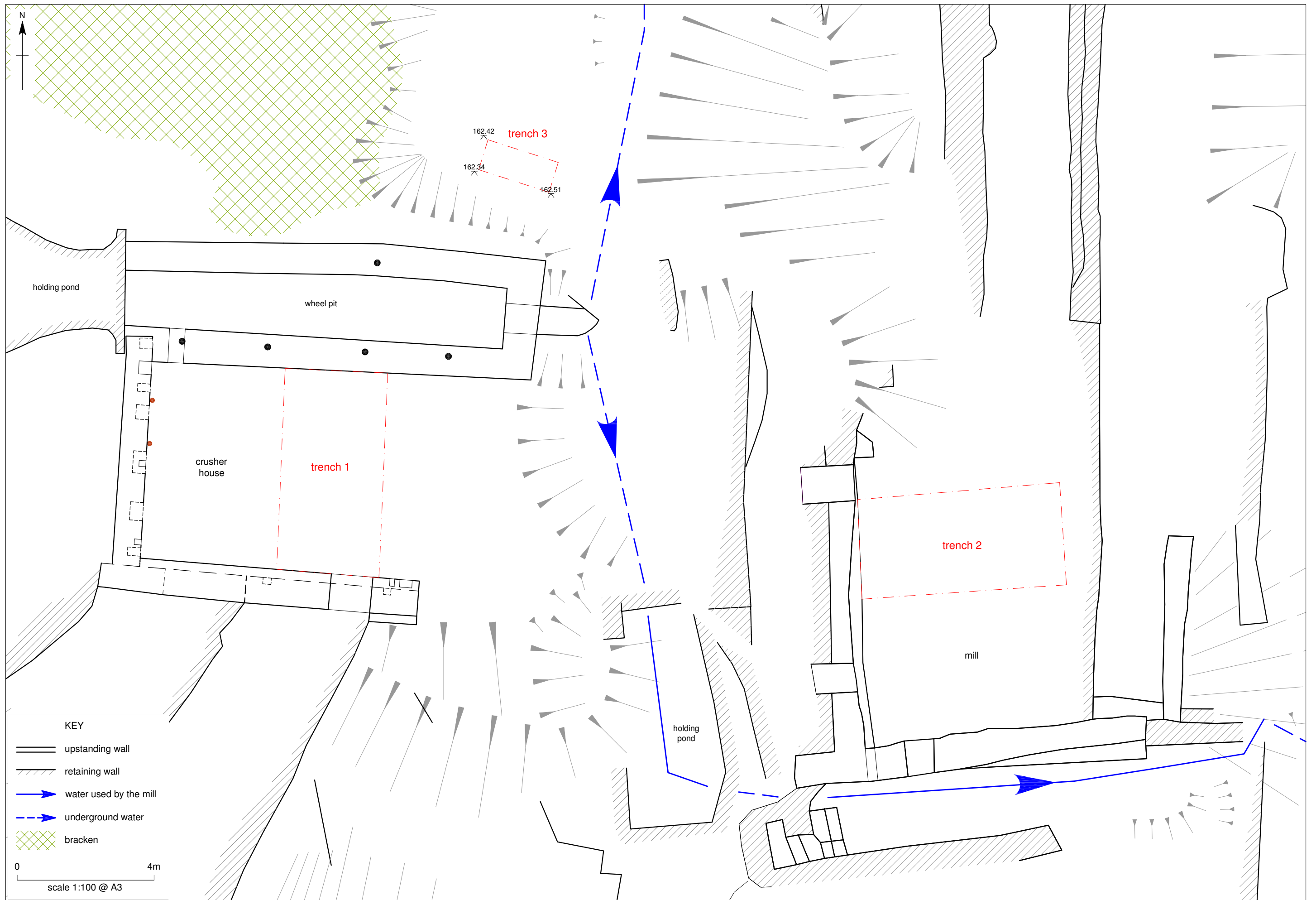
The results of the analysis found no discrete bodies made of copper or copper oxides indicating that they are not abundant in the soil. The copper content is high (roughly 0.1% by weight) relative to the average in the earth's crust (roughly 0.01% by weight), but as the building is in an area with abundant copper seams these values may represent natural concentrations for the soils in the area. No fragments of discrete copper or copper oxide bodies that could be associated with copper processing activities were detected within the soil matrix during SEM imaging. Rocks containing large amount of barium minerals (Figure 8) up to 100 microns in size, on the other hand, were somewhat common in the soil matrix. Barium is found in roughly the same bulk concentrations as copper (Ba 0.14% by weight vs Cu 0.1% by weight). The absence of large copper bodies, similar to those found composed of barium, suggests that the copper grains in the soil are either highly weathered and of a very small size and/or bound up in other naturally occurring rocks or minerals. Thus, the analysis of soil sample PRE17 yields no conclusive evidence that the building from which it was extracted was used for processing copper.

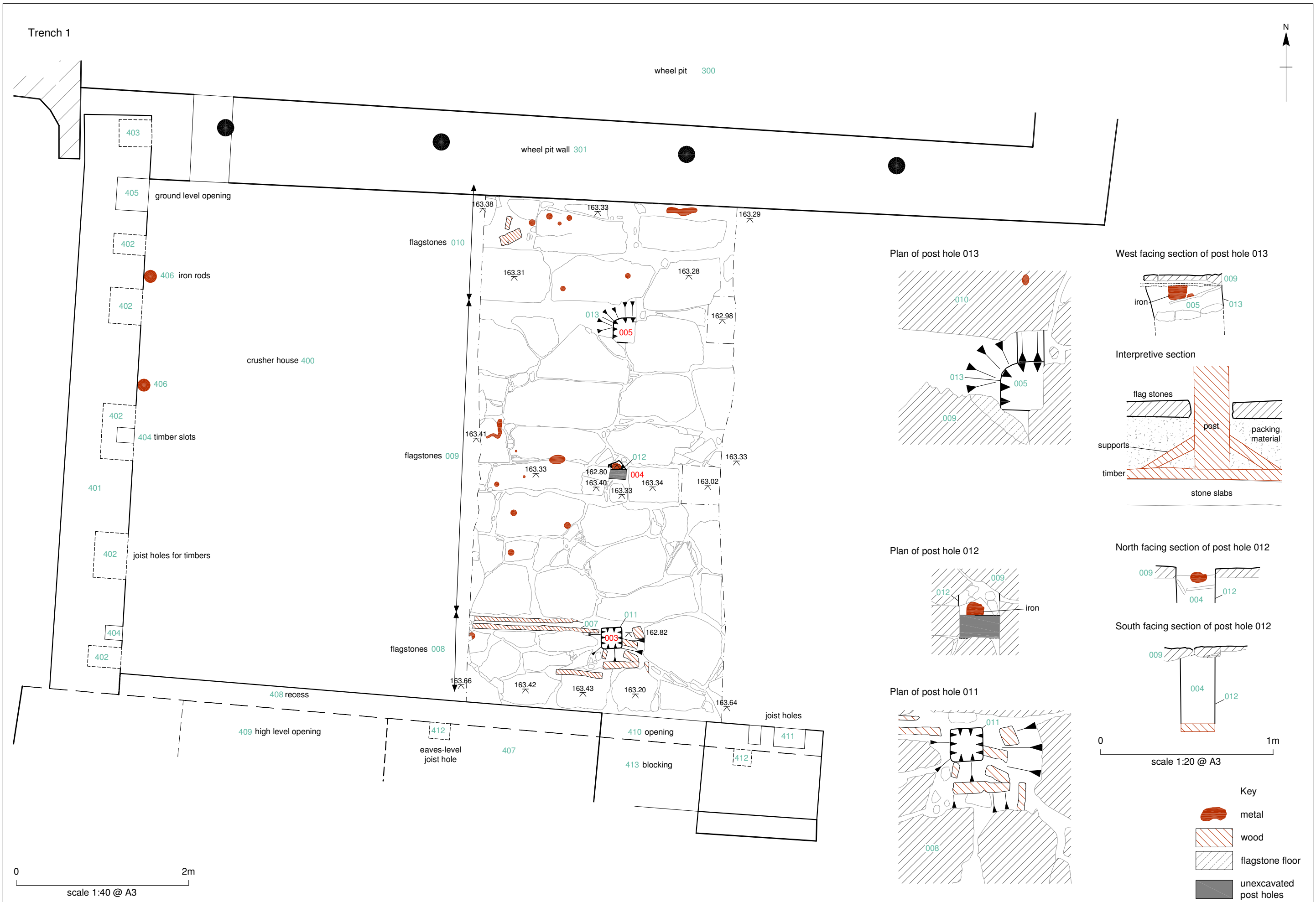
Table E2: XRF results

0.001	Pd Err	Oxide:3phase	Method
<LOD	Cd	90	Elapsed Time
0.0011	Cd Err	<LOD	MgO
<LOD	Sn	1.6035	MgO Err
0.0064	Sn Err	2.2796	Al2O3
0.0224	Sb	0.2607	Al2O3 Err
0.0044	Sb Err	12.859	SiO2
0.0003	Te	0.3207	SiO2 Err
0.0002	Te Err	<LOD	P
0.1428	Ba	0.0105	P Err
0.0104	Ba Err	0.4236	S
<LOD	La	0.0194	S Err
0.0123	La Err	<LOD	Cl
<LOD	Ce	0.0166	Cl Err
0.0148	Ce Err	1.5304	K2O
<LOD	Hf	0.0248	K2O Err
0.0027	Hf Err	0.0841	Ca
<LOD	Ta	0.0056	Ca Err
0.0022	Ta Err	0.1561	Ti
<LOD	W	0.0134	Ti Err
0.0049	W Err	<LOD	V
<LOD	Pt	0.0078	V Err
0.0021	Pt Err	<LOD	Cr
<LOD	Hg	0.0034	Cr Err
0.0009	Hg Err	0.1103	Mn
<LOD	Tl	0.0055	Mn Err
0.0018	Tl Err	5.7076	Fe
0.3556	Pb	0.0328	Fe Err
0.0081	Pb Err	<LOD	Co
0.0025	Bi	0.0055	Co Err
0.0022	Bi Err	0.0035	Ni
<LOD	Th	0.0021	Ni Err
0.002	Th Err	0.1025	Cu
<LOD	U	0.0029	Cu Err
0.0024	U Err	0.0417	Zn
Passed	Cal Check	0.002	Zn Err
		0.0023	Ca
		0.0014	Ca Err
		0.1441	As
		0.0046	As Err
		0.0004	Se
		0.0003	Se Err
		0.016	Rb
		0.001	Rb Err
		0.0023	Sr
		0.0004	Sr Err
		<LOD	Y
		0.001	Y Err
		0.0205	Zr
		0.0012	Zr Err
		<LOD	Nb
		0.0005	Nb Err
		<LOD	Mo
		0.0009	Mo Err
		<LOD	Rh
		0.0009	Rh Err
		<LOD	Pd



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Trench 1 - pre-excitation plan showing rubble layer 002



wheel pit 300

wheel pit wall 301

002

flag stone floor

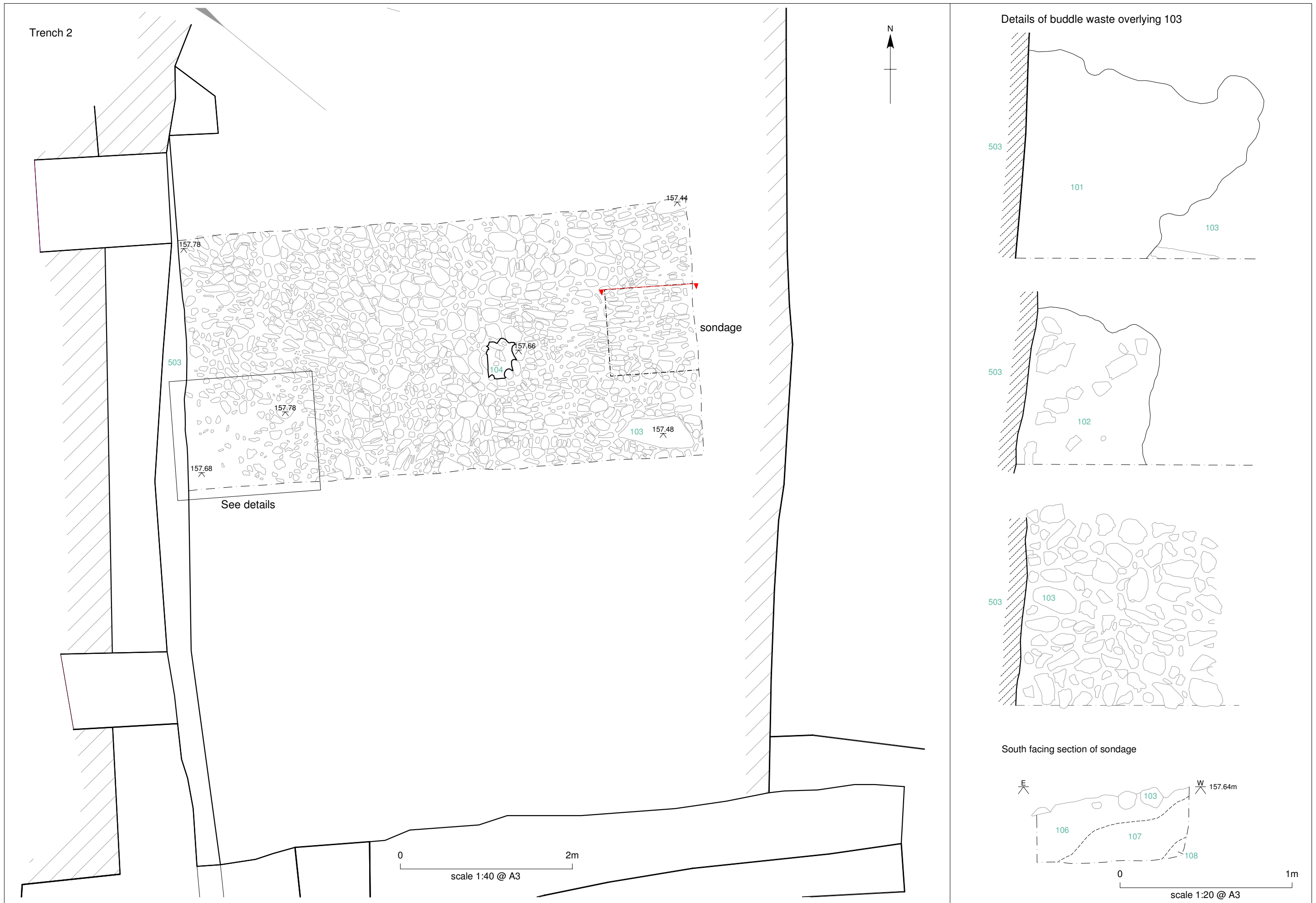
crusher house 400

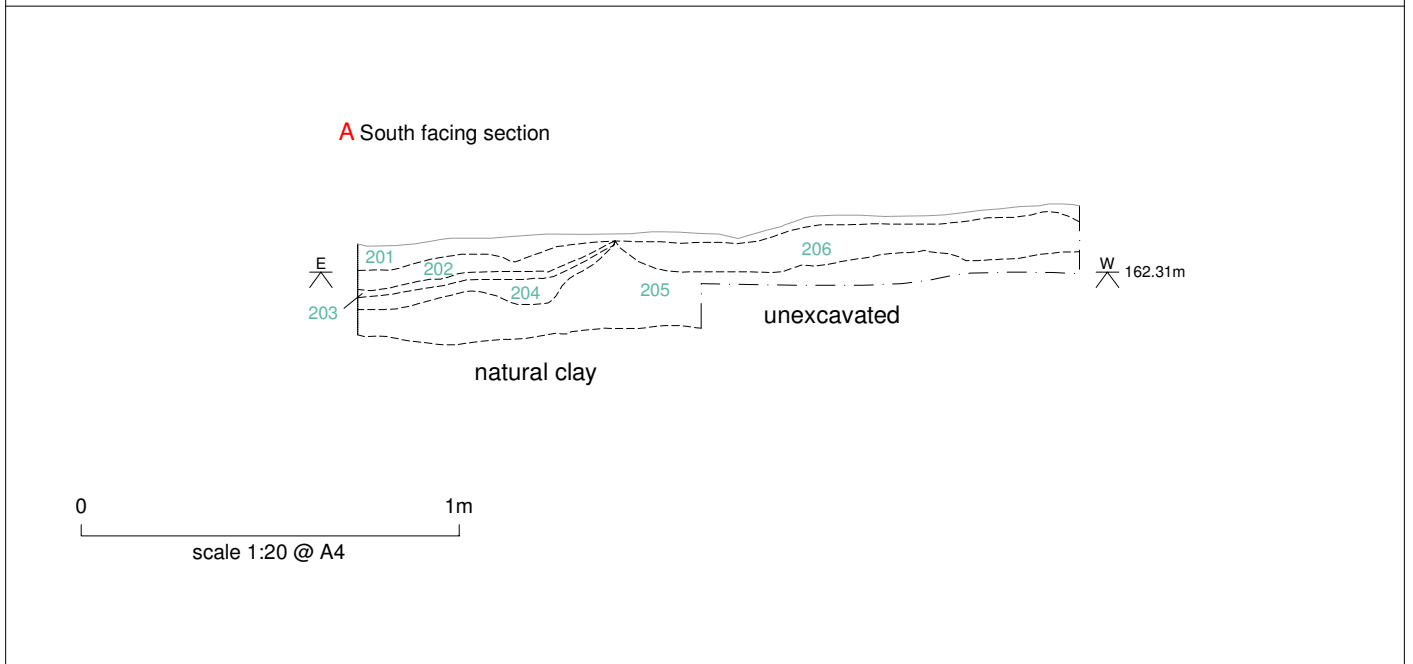
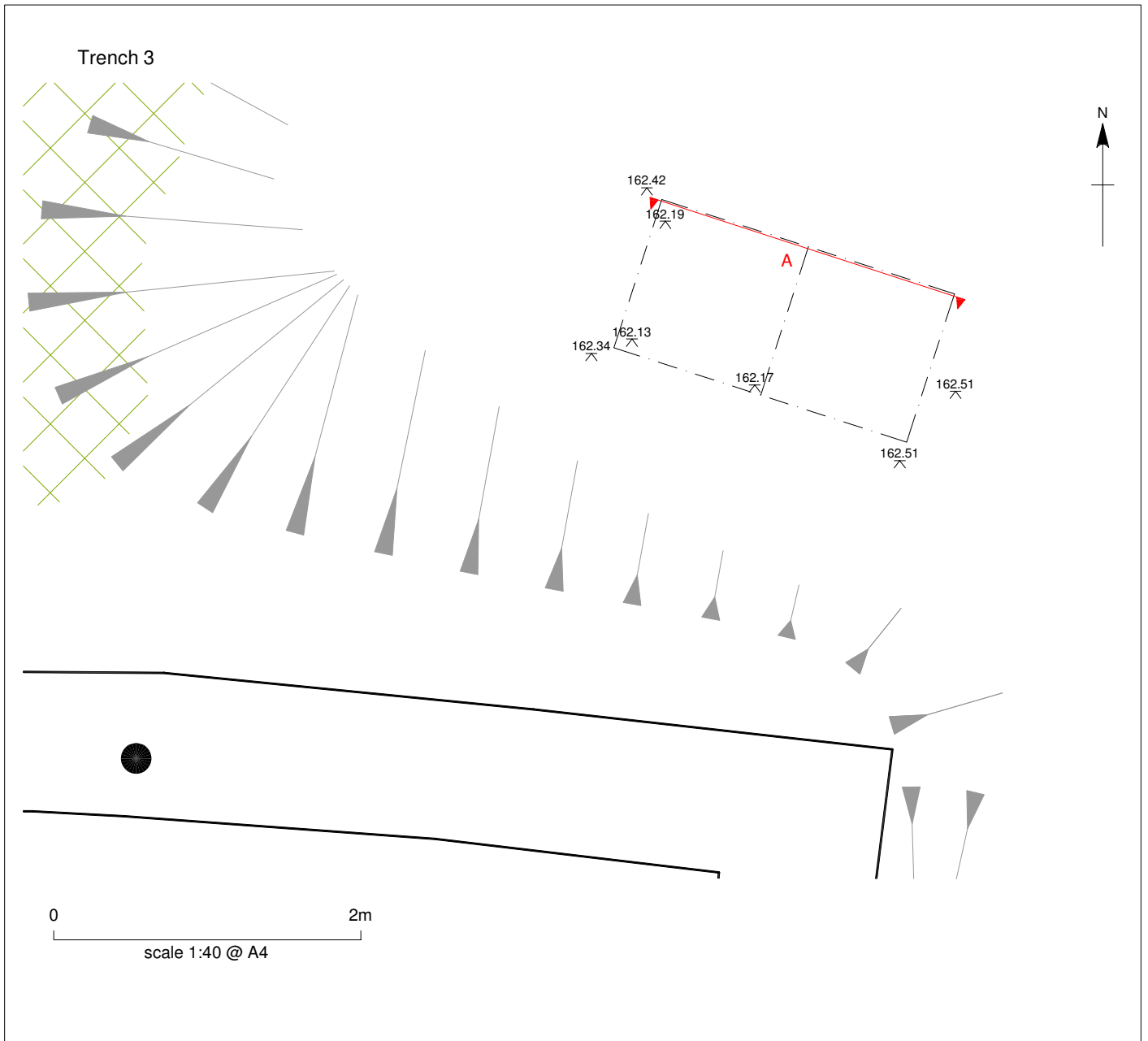
002

crusher house wall 407

0 2m

scale 1:40 @ A4

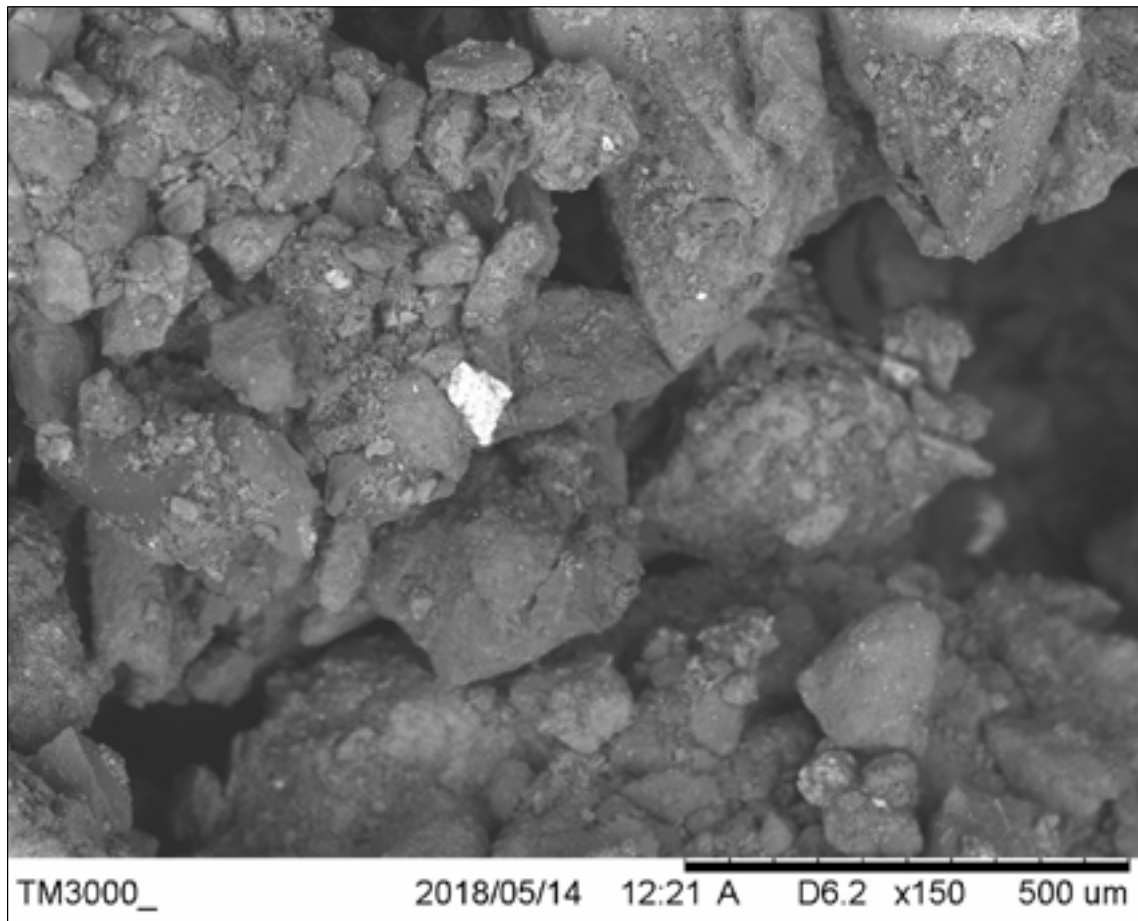




©NAA 2017 Penny Rigg copper mill Community Excavation, Cumbria: Trench 3 plan and section Figure 6



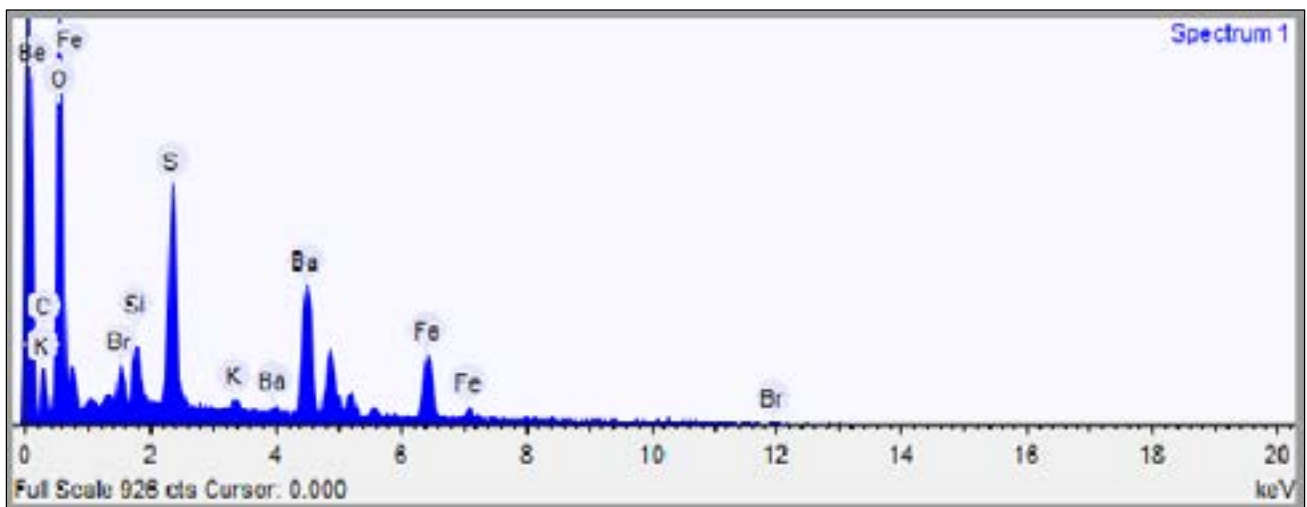
0 5cm  
scale 1:1 @ A4



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*Penny Rigg copper mill Community Excavation, Cumbria: Back-Scattered SEM image of PRE17 showing bright grain roughly 100 microns in size. Analysis by Energy dispersive x-ray spectrometry (EDS) showed the body to be composed mostly of barium. All bright bodies in the image were analysed and none showed significant copper content. (Image courtesy of Durham Archaeomaterials Research Centre)*

Figure 8



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*Penny Rigg copper mill Community Excavation, Cumbria: EDS spectrum of barium-rich grain. (Image courtesy of Durham Archaeomaterials Research Centre)*

Figure 9