MYNYDD PARYS

DYFFRYN COCH PRECIPITATION PITS

SURVEY AND RECORDING

G36

REPORT NO. 193

YMDDIRIEDOLAETH ARCHAEOLEGOL GWYNEDD

GWYNEDD ARCHAEOLOGICAL TRUST

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APPENDICES

PLANS (in separate pocket)

1 INTRODUCTION

1.1 The archaeological importance of Mynydd Parys is summarised in paragraph 4.1, and has been described elsewhere (Rowlands, 1981; Hope, 1994; Briggs, 1992; *etc.*).

1.2 The project to survey and record a series of precipitation and ochre pits along the southern side of Mynydd Parys, Dyffryn Coch (SH449905), has had a complicated history, and it was thought that a brief summary of the background and development of this project was necessary.

1.3 Anglesey Mining plc was originally granted outline planning permission in May, 1986, for the development of a mine at Parys Mountain for the exploitation of zinc, copper and lead sulphide resources identified as lying beneath the north western slopes of the mountain. No archaeological conditions were attached to the permission. The area with planning permission is shown on figure 1 as a black line described *Existing permission*.

1.4 A further application (1/11/C/77a) was submitted by Anglesey Mining to Gwynedd County Council in February, 1991, to extend the tailings disposal area on the southern side of the mountain (see figure 2) outside the area of the existing planning boundary. The Trust recommended (letter dated 13th March 1991) that an archaeological assessment be carried out in advance of the application, but this advice does not appear to have been heeded.

1.5 In December, 1991, the Trust applied to Cadw for grant-in-aid to allow them to record the precipitation pits and vitriol works before they were destroyed by the tailings lagoon. This report is on the work carried out as a result of that grant.

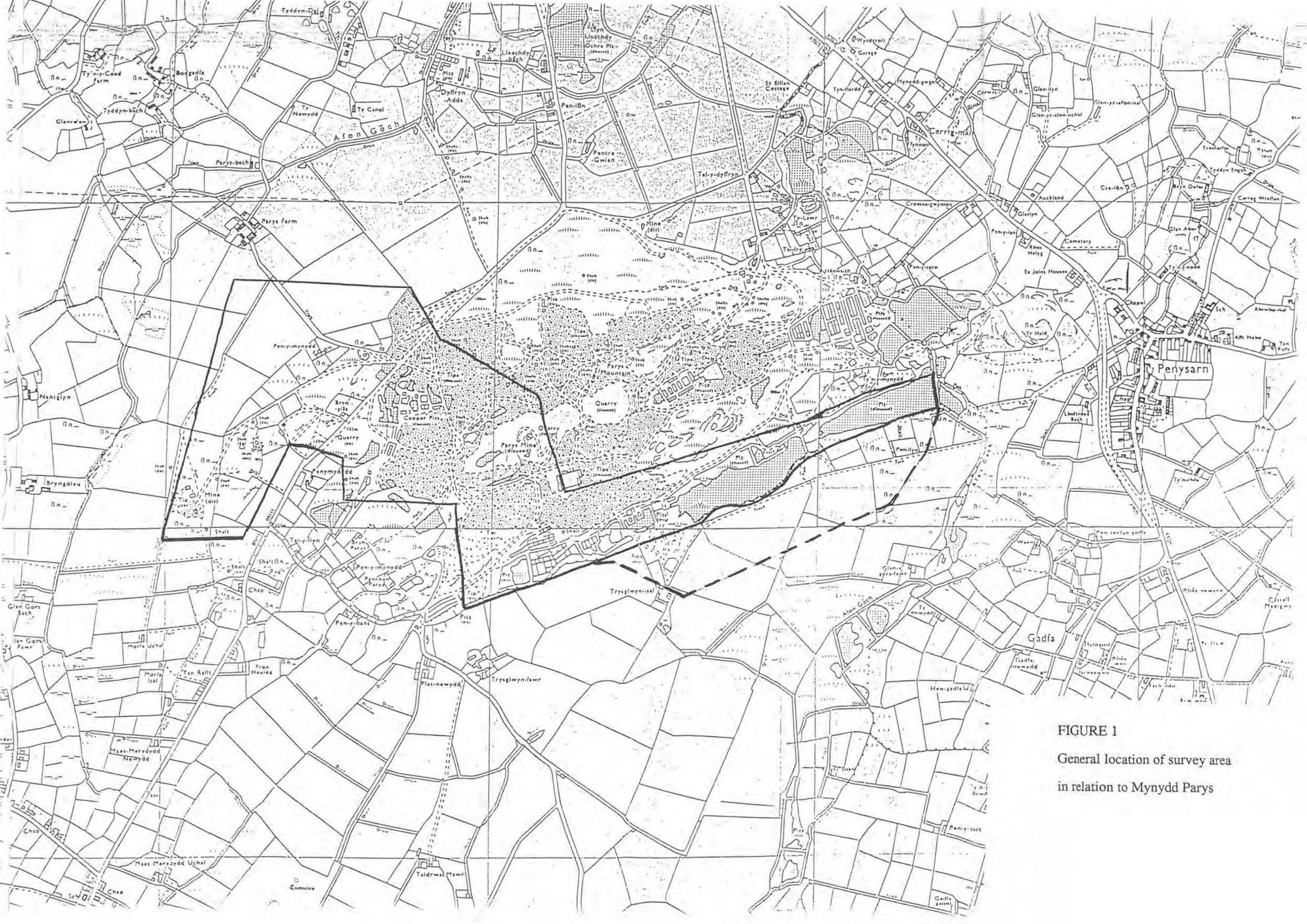

FIGURE 1

General location of survey area

in relation to Mynydd Parys

2 PROJECT BRIEF

2.1 Introduction

2.1.1 No detailed project design was drawn up for this project. However, the project as it was finally carried out was based on a suggested programme of works made by S D Boyle in 1991, with additions by D Thompson in 1995.

2.2 Suggested programme of work - S Boyle, 1992

2.2.1 This programme of work was suggested immediately following a site visit by S Boyle on 6th December, 1991. This informed the bid for grant-aid to Cadw. The following sections 2.2.2 - 2.2.5 are taken directly from S Boyle's visit report and are in his words.

2.2.2 Description

The area to be flooded by the new tailings dam was walked over, and the most obvious features were sketched on to a site plan (1:2500). The copper pits and ochre pits are well preserved, and although the outlines of many of them appear on the 1924 OS 1:2,500, a much more detailed (analytical) plan could be obtained. In particular, at the east end of the dam area, waste has settled in a series of low, roughly rectangular mounds which suggested that this area was formerly subdivided (by wooden fences? or by stone walls? now totally submerged).

2.2.3 Other points of interest included the following:-

i) to the north of Trysglwyn-Isaf farmhouse (itself derelict) is an area of tips which is still not overgrown. Survey/description/sampling of these is desirable.

ii) a copy of the 1924 OS 1:2,500 in the Trust has been annotated 'VITRIOL WORKS LOST", immediately north of tips (i). [Annotation by GCC?] This area is now overgrown with gorse and was given only a cursory examination, but wall foundations do survive here. The pits associated with them (see Arch Camb 1965) may be identifiable to the south east.

iii) at the north end of one of the dams across an ochre pit (marked on sketch plan) is a low, square, stone pillar, marked 'N' on its south face, 'A' on its north. Presumably this is a boundary marker. Amlwch parish/Amlwch Rural district lies to the north, but the OS 1924 map shows the boundary running along the south edge of the ochre/copper pits, and the area to the south is Rhosybol PH/Twrcelyn RD, so I [SDB] *don't know what 'N' stands for.*

2.2.4 Recommendations for response

(i) Full description of the surviving pits, watercourses, trackways, with photographs. Consider an elevation drawing of some of the better preserved walls to show techniques of construction.

(ii) Investigation of the site of the vitriol works to identify foundations, pits etc.

(iii) Description and sampling of waste tips.

(iv) Full and detailed resurvey of the area.

(v) Consider trenching one or two copper pits to establish depth (maybe too dangerous).

2.2.5 Timing

a) documentary research	
i)	*3/4 man days*
b) fieldwork	
i) descriptions and photographs	*8/10 man days*
ii) vitriol works	*1 day*
iii) waste tips	*1 day*
iv) re-survey of the area	*8 days*
v) trenching	*2 days*
c) post survey	
i) survey processing	*3 man days*
ii) report writing	*3 man days*
iii) draughting	*2 man days*
total	*32 man days*

2.3 Request for funding - 1992

2.3.1 This suggested programme was summarised in a letter from GAT to Cadw, dated 9th December, 1991 (reference 1209pf35), as

An adequate record of these extensive works which extend over an area of 20-25 ha should include: full description, with photographs, of surviving pits, watercourses, trackways (some elevations may be drawn to demonstrate construction techniques); full survey of the area; attempt to locate and record site of the Vitriol works (believed to be under dense gorse); to record possible parish boundary marker stone.

2.3.2 The Trust's request for grant-in-aid of £1700 was accepted by Cadw in a letter dated 10th January, 1992.

2.4 Work programme revised - 1995

2.4.1 Unfortunately, S Boyle left the Trust in 1992, after completing part of the documentary and fieldwork (features north-east of dam 109 had been surveyed by EDM, and most had been described in some detail). At the end of 1994, the work had not progressed any further and the present authors took over the project.

2.4.2 The original programme of work was subsequently revised in June, 1995, during a site visit by D Thompson and D Gwyn (see below paragraph 3.2.1). The first problem to resolve was the actual extent of the area to be surveyed. Figure 4 in the planning application (reproduced as figure 2 in this report) showed the envisaged extent of the tailings lagoon after 15 years' deposition (presumably the maximum planned extent) as reaching as far south-west up the valley as the pit which has subsequently been labelled feature 71. As this feature was in the lower part of a system which began further up the valley (*i.e.* to the west), it was decided to plan the whole of this sytem and thus the dam (1), the beginning of the system, was selected as the end point of the survey area.

2.4.3 It was decided that the archive report should contain the following sections: general introduction, project design, fieldwork methodology, historical summary of precipitation pits and vitriol works, a set of results and conclusions, a bibliography, a gazetteer, a sample set of photographs, and a series of plans showing i) the extent of the whole survey area, ii) a series of plans at larger scale showing the features numbered as per the gazetteer and iii) a series of plans showing how the water-flow system worked. This is how the report and figures have been laid out.

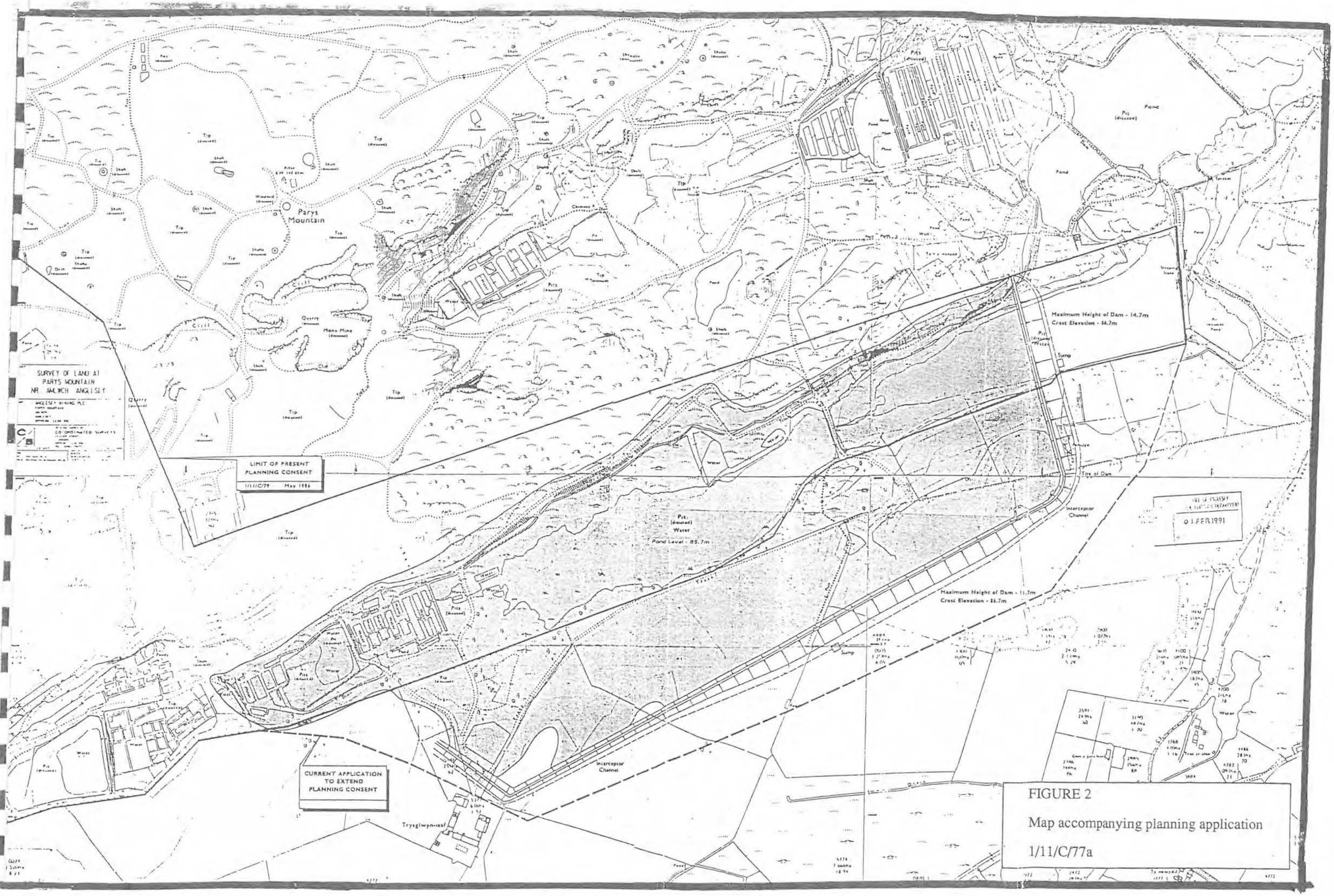

FIGURE 2

Map accompanying planning application

1/11/C/77a

2.4.4 In order to achieve this it was agreed that the following tasks needed to be carried out - finish the EDM survey up to the dam selected as the endpoint; merge this survey data with the previous survey; produce working copies of the survey at A3 size (approximately 1:500) to be used as base plans for descriptions, with a masterplan at 1:2,500; number and describe all the features for the gazetteer; take photographs; transcribe written fieldwork details; carry out additional archive work; compile report; label and cross-reference photographs; compile and order archive; write a short report for *Archaeology in Wales*; consider longer report for an industrial archaeological journal if the results warranted it.

3 FIELDWORK METHODOLOGY

3.1 Phase 1

3.1.1 The first phase of fieldwork was carried out between 21st January and 29th April, 1992, by S Boyle and M Mason. The EDM survey began at the north-east end of the area and continued south-westwards as far as the feature now labelled 109. All man-made features (walls, pits, dams *etc.*) were recorded by a sufficient number of points to allow their size and shape to be properly represented at a scale of c. 1:1000.

3.1.2 Features now labelled 171 - 193 were then described in detailed notes on permatrace overlays to the EDM survey.

3.1.3 Note: the features were numbered only during the second phase of working (*i.e.* 1995) which began at the other, western, end, thus the high numbers for these features.

3.2 Phase 2 - planning

3.2.1 The second phase of fieldwork was carried out by D Gwyn, A Shallcross and D Thompson between 6th and 11th July, 1995, following an initial site visit on 9th June. During that latter visit, the following comments were made which informed the approach subsequently taken to recording the area.

3.2.2 Three systems of original workings, not entirely self-contained, were represented in the area which would be drowned by the tailings lagoon. For the most part, the systems appear to have worked on a gravity-assisted water-flow process, in which one pit led directly into another.

3.2.3 However a number of problems were identified which might hinder a full and proper recording and understanding of the site:

i) part of the water-flow system may have been carried out by wooden ducting, none of which survives (*N.B.* parts of the wooden sluices do exist still):

ii) there is the distinct possibility that the systems were modified while in use:

iii) some parts of some of the systems have been damaged subsequently - *e.g.* whilst the underground channels which fed the top and the middle system are apparent, crushed stone appears to have been tipped over the mouth of the channel (feature 117) which fed the bottom system:

iv) this is the first attempt to try to record and explain a system such as this which, anyway, is very rare, and there is no previous, comparable, material to which to refer:

v) surprisingly little documentary information relating to the pits and their operation survives:

[ADDENDUM: papers recently deposited by Mrs Fanning Evans with UCNW archives are now in the process of being catalogued]

vi) there is no way of dating the systems, although generally it is assumed that the earliest systems are those at the highest level (*i.e.* at the south-west end) (see paragraph 4.2.7).

3.2.4 It was decided to record the precipitation pits in such a way that they could be presented as the physical remains of an industrial process. It was considered most important to understand how the process operated, and to present that in the report in a meaningful way. Detail such as the actual construction of walls, pits, dams *etc.* was less important, and would have involved time and resources beyond those available within this project.

3.2.5 For this reason it was decided to adopt a slightly different approach to that used in the first phase of survey: the EDM survey would be continued at the same level, but the detailed descriptions of individual items giving height, width, nature of construction *etc.* were to be replaced by the division of the area into basic component parts (wall, pit, dam leat, channel *etc.*), which would simply be given a number on the plan (see plans 1 and 2) and added to the gazetteer. It was decided that it would be far too time-consuming to label and describe each section of wall within each feature individually: anyway, it was intended that much of the detail would be visible on the photographs. Any further information which would explain the function of the feature would also be added to the gazetteer.

3.2.6 At the same time, the water-flow system would be worked out and also added to (another) plan (see plans 3 and 4). This would allow a sequence to be established which would hopefully explain how the systems worked.

3.3 Phase 2 - work

3.3.1 The EDM survey was completed first, again taking sufficient points to allow the true shape and size of all the features to be reproduced on a plan at c. 1:500 scale (maximum). This data was then merged with the earlier survey data to produce a composite plan of the whole area. Next a series of hard copy plans were printed out to act as the basis for the recording and descriptions: an overall plan at c. 1:2,500 acted as the master, and the area was divided into five smaller units which were printed out on A3 sheets at c. 1:500 scale. These insets (numbered 1 - 5, moving south west to north east) formed the bases for recording, and five copies of each inset (labelled a - e) were used to record five different sets of data as follows.

3.3.2 Inset A. These contained notes made on the initial site visit (7/6/95) both on the existing survey, its extent and level of detail, which allowed the revisions to be made to the programme of work. It did not, of course, cover the whole area. Weather conditions at the time precluded their permanent retention in the archive.

3.3.3 Inset B. This contained brief notes along with a series of arrows which showed the probable direction of the flow of the water from one pit to another, and along a number of channels.

3.3.4 Inset C. These contained additions, alterations and deletions to the EDM survey which were noted when the descriptions were being made, and which were effected manually in the office.

3.3.5 Inset D. The feature numbers were written on these, whilst the gazetteer was simply listed manually on paper as a number followed by brief description. It was not thought appropriate that special recording forms be created for this purpose.

3.3.6 Inset E. These formed the basis of the photographic record. As the photographer took the photographs, and an assistant placed the scales, another assistant marked the position of the photographer, the direction in which the photograph was being taken and the number of photographs (black and white and colour slide) taken. It had been decided that it was not feasible simply to catalogue the photographs by feature number, as very few of them actually contained only a single feature.

3.3.7 In summary, the insets recorded
a = initial notes on SB's survey (not retained):
b = notes (including directional arrows) on the water-flow system:
c = additions/alterations to be added to the EDM survey:
d = features numbered, other notes *etc.*: and
e = photographs.

3.3.8 For information, inset 5 contained features 1 - 72, inset 4 contained features 73 - 113, inset 3 contained features 114 - 169, inset 2 contained features 170 - 183, and inset 1 contained features 184 - 195. These are, of course, retained in the site archive.

4 HISTORICAL SUMMARY AND SYSTEM OF WORKING OF PRECIPITATION PITS AND VITRIOL WORKS

4.1 Mynydd Parys copper mines.

4.1.1 The copper mines at Mynydd Parys were developed from the 1760s onwards. Mynydd Parys mine itself was worked from 1785 on the western part of the site on land owned jointly by Plas Newydd and Llys Dulas by the lawyer and industrialist Thomas Williams "the Copper King", one of the leading figures of the industrial revolution, who for a number of years effectively controlled the British copper industry (Rowlands, 29-30; Harris *passim*). Mona mine to the east was on land owned solely by Plas Newydd, and was worked by Roe of Macclesfield from 1864.

4.1.2 Mynydd Parys's golden age was the last quarter of the eighteenth century, when 1,200 people might be employed and output might exceed 3,000 tons per annum, but by 1800 operations were already in decline, and underground extraction effectively ceased in the 1880s.

4.1.3 Though the sites have always been called mines, much of the ore came from a large opencast pit, and both mines practised another system, whereby ore was obtained from precipitation from the water which accumulated at the bottom of the workings - a method which may be appreciated by the fact that a key dipped in water from the workings will become covered with copper in a matter of seconds. Ochre was also extracted from the water, and a vitriol and alum works functioned for part of the mines' history.

4.1.4 Exact dates for much of the work that went on at Mynydd Parys are elusive, owing to the incomplete survival of the mines' archives. The Mona mine records survive partially intact, but only scattered documents now exist for the Parys mine. It is not known when ochre extraction began, nor when the vitriol works was established.

4.2 Precipitation pits.

4.2.1 Experiments to extract copper ore from Mynydd Parys water were carried out as early as 1579 at the request of the Society for the Mineral and Battery Works, but were not pursued further (Hope, 75; NLW *Calendar of Wynn Papers* 455, 456, 460, 462). Commercial exploitation by this method is attested from as early as 1772 (Rowlands, 43, 166) and continued as late as 1958, long after actual mining ceased in the second half of the nineteenth century (uncat. mss, UWB manuscripts dept).

4.2.2 The way the system worked was, in outline, as follows. Water was either drawn up from the mine, initially in buckets hauled by whimseys and later by windmills and steam pumps, or it was drawn off through drainage tunnels, and emptied into the *pyllau heiyrn*, as they were known locally, ponds which were originally sited wherever convenient over the mountain, but which came to be concentrated at four main areas - Dyffryn Coch (SH44169013, in existence by 1786), Mona mine (SH447904, by 1839), Tal y Llyn (SH438898, by 1815) and Parys north-west (SH437904, by 1815). Other systems were at Dyffryn Adda (SH438915) and Llyn Laethdy (SH442915).

4.2.3 The pits were typically between 20 - 36ft long, 12 - 15 ft wide and 18 - 22 ins deep. They were set at about 6' or 7' apart and at different levels, enabling them to be drained for cleaning or for removal of the ore (Hope, 77: Rowlands, 43).

4.2.4 The pits were altered and extended, doubtless many times although precise documentation is lacking. The method of precipitation, however, remained the same: large quantities of iron, shipped in from as far afield as London, were left in these pits and regularly turned over by miners, wielding long wooden poles, until they dissolved, leaving copper precipitate mixed with mud at the bottom of the pit. Any scrap iron would serve the purpose: Pennant records that "old pots, hoops, anchors or any refuse will suffice ... " (Pennant, 279) and he later observed kettles, shovels and meat tins being used. The precipitate was then removed by cart, first to a drying kiln and then to a smelter.

4.2.5 These copper ponds were constructed as near as possible to an outfall, and the water would subsequently pass through as many as five separate ponds.

4.2.6 The precipitate thus produced was very impure, containing only about 20%-30% of metallic copper (Foster and Cox, 659). However, between 1857 and 1924, no less than 19,000 tons of precipitate, yielding 2,000 tons of fine copper, were produced (Hope, 79).

4.2.7 As far as dates for the precipitation pits included in the survey are concerned, all that can be said is that the most westerly were, and the central ones appear to have been, in existence by 1786 in something like their present form (UWB General collection 31603), and the most easterly by 1839/41, when they are shown on the first edition 1" Ordnance Survey map. Most of the pits were probably abandoned when mining ceased in the 1880s, since a map of 1912, comprising part of LIRO WCD 118/19, shows the Dyffryn Adda and Llyn Llaethdy precipitation pits leased to Fanning Evans, suggesting that these were the only ones to remain in use into the twentieth century. Work went on here until 1958 (uncat. ms, UWB).

4.2.8 Precipitation pits were not unique to Mynydd Parys, as has sometimes been claimed, but they were not to be found elsewhere in Gwynedd, and were rare anywhere in the copper industry: they are not mentioned, for instance, in the great sixteenth century textbook on mining practices, Georgius Agricola's *De Re Metallica* (1556).

4.2.9 The remains at Mynydd Parys have no parallels in Great Britain, and their international importance is only underlined by the fact that one has to look to Spain for comparative material. Precipitation was practised at one time at the Rio Tinto mine in Spain, as well as a system of leaching the ore either after it had been burnt in heaps, or as a mixture of burnt and unburnt ore (Foster and Cox, 658; Atkinson, 11).

4.2.10 Willies (1989) has described the Rio Tinto precipitation pits in detail. Lower grade copper was enriched by burning off sulphur in heaps, known as *teleras*, and the burnt ore was then either shipped or "was irrigated with acid-water .... and the liquor produced 'cemented' by passing it through a labyrinth of channels in which iron scrap was placed. Copper was precipitated as a black sludge. The dry process (*i.e.* burning) was replaced by a wet one. Pyritic ore was placed in vast heaps with channels under, and then irrigated by forming ponds on its surface. After a time air was again allowed to enter, and the procedure repeated. The surface on some heaps in the 1920s was 'ploughed' and sprayed instead. This broke down the cupriferous pyrite to a copper enriched liquor, iron oxides (left in the heap) and after cementation, a vast quantity of ferrous and ferric sulphate rich fluid, which further deepened the rich red colour of the Rio Tinto."

4.2.11 Her plate 6 (*ibid*, 73) shows the cementation troughs, and the caption reads *"Low grade cupriferous pyrite was at first roasted in conical heaps to oxidise it to soluble sulphate, but later exposed to water and air alternately. Water drained from the heaps was conducted to the cementation troughs shown here, containing scrap iron, to precipitate any copper. All the work here was manual - later troughs , c. 1920, used a crane and magnet to handle the scrap"* (Willies, 72-3).

4.2.12 Copper precipitation is also recorded at Hern Grundt in Hungary, at Cronebane, in the important Wicklow copper mining region centered on the town of Arklow (LIRO WCD 118/19; Hope, 77; Irish 6" Ordnance Survey, Co. Wicklow), and in Germany, Italy and Spain (UWB Mona Mines collection, 2113).

4.2.13 Cronebane was worked by the Macclesfield Copper Company through its subsidiary, the Associated Irish Mine Co., from 1787 to at least 1808 and possibly later (Weaver *passim*), and the Macclesfield Company leased Mynydd Parys from 1764 until 1785 (Rowlands, 23). It is possible that the precipitation process was a method with which Messrs Roe of the Macclesfield Company were familiar, although there is no record of their having used the system at their earlier ventures at Alderley Edge (Carlon, *passim*).

4.3 Ochre pits.

4.3.1 Spent water, by this stage (having passed through a series of precipitation pits) a strong solution of iron sulphate, was used to make ochre, a base for paint. Whilst still in the last precipitation pit it was agitated, and then diverted into large shallow ponds, where it was allowed to stand. It became further oxidised by absorbing oxygen from the air and settled as a fine yellow precipitate. It was redirected several times into different ponds, and the ochre was allowed to drain before being taken (probably by cart) to covered drying floors where it dried out naturally. The ponds were run dry every two or three months according to the strength of the iron solution (Foster and Cox, 659). Coal-fired kilns, probably the same ones used to dry the copper precipitate, completed the task of drying. The dry ochre was then ground in a windmill to a fine powder.

4.3.2 It is not clear when this system was introduced. A map of 1786 shows the "iron pits" and larger, irregularly-shaped adjacent reservoirs at the Mona mine (at a site which has now been tipped over), but is not clear whether these were simply for outflow or whether they were for ochre (UWB General collection, 31603) - more probably the former. Ochre extraction was certainly practised, or at least contemplated, by 1810, when an improved plan for precipitation and ochre pits was drawn up but not, apparently, acted upon (UWB Mona Mine 3646). The first edition 1" Ordnance Survey map of 1839/1840 shows the large ochre pools in Dyffryn Coch, although it does not label them as such, but the large reservoirs lower down the valley, and their attendant precipitation pits, are labelled. Only at Dyffryn Adda, to the north, are "paint pools", presumably for collecting ochre, noted.

4.3.3 Ochre was also extracted at Parc yr Ocar ("Ochre Parc") on the Penrhyn estate, in Dyffryn Ogwen, from 1794 to 1839, but does not seem to have been processed there (Boyd, 23). There is no record of ochre being extracted anywhere else in what is now Gwynedd.

4.4 Vitriol works (*y gwaith fudrol*).

4.4.1 Another use to which the spent iron sulphurate water was put was the manufacture of sulphuric acid, a substance which continued to be called Vitriol even after it ceased to be made from green vitriol. The vitriol works at Trysglwyn Isaf was in existence by 1797 when it is recorded by Aitken (Hope, 76), and from 1803 it was leased to Dr Joseph Parr, a manufacturing chemist from Carmarthenshire, as the Mona Vitriol Company. The copperas, or green vitriol, which was extracted there was used in the manufacture of pigments and dyes (Hope, 75-6). The site of the works is marked on a map of 1835 (UWB M/C/3/158), though curiously Abraham Rees' *Cyclopaedia* (c. 1817-1818) quotes the chemist Watson, Bishop of Llandaff, as saying that no such manufactory existed at the time of his visit, for which no date is given. This may have been as a consequence of an improvement in the making of acid, which came to be derived from sulphur rather than vitriol, and which depressed the vitriol trade (Rees, 1, xii, 4, 310-11) and perhaps the Trysglwyn site was re-established subsequently to produce sulphuric acid.

4.4.2 Vitriol was also produced elsewhere on Mynydd Parys, at Cae'r Pandy from 1799 (Hope, 76).

4.4.3 Alum, for use in the preparation of dyes and pigments and in tanneries, was also extracted at the *gwaith fudrol*.

4.4.4 An early account of the manufacture of vitriol is given by the Siennese Vannoccio Biringuccio in his *Pirotechnia* (Biringuccio 1540), who describes a process involving the leaching of the ore (by exposure to wind and rain) for five or six months, during which time the ore-heap is turned over occasionally. It is then kept under cover for a period of six to eight months before being placed in a pit half-filled with water until it has dissolved into a sludge. The earth then drops to the bottom and the liquid is passed to an adjacent tank, where it is boiled in lead receptacles with an admixture of scrap iron. When the water becomes congealed it is taken out and allowed to stand in a vat. The congealed vitriol is either put into a boiler to be melted or poured directly into moulds. The better cakes are made by successively congealing and liquifying the vitriol (Biringuccio, 95-7).

4.5 Iron oxide production.

4.5.1 Another by-product of the vitriol-making process was iron oxide from the ponds, which was sent off to gasworks for use as a purifier.

5 RESULTS AND CONCLUSIONS

5.1. General.

5.1.1 The series of pits, ponds and leats in the small valley immediately south of Mynydd Parys formed part of the Dyffryn Coch sequence, which makes use of the topography of the land to the south of the mine workings. Five separate sequences of precipitation and copper pits can be observed here, of which three fall within the area of the proposed lagoon and have been surveyed (see paragraph 2.4.2). The most westerly of these, the Tal y Llyn precipitation pit and ochre pond is not under threat, and was not surveyed.

5.1.2 Each of the three systems surveyed used water draining from the Great Opencast. This was the most highly concentrated of all the waters to come from either Parys or Mona mine (Hope, 78), and accordingly the system developed at Dyffryn Coch became the most extensive on Mynydd Parys.

5.1.3 Photographs of the pits in use appear in Griffith Owen, Pensarn's *Mynydd Parys*, published at Caernarfon in 1897. The pathways between them were known as *llwybrau Cadi Rondol* ("Catherine Randles' pathways"), after one of the *coparledis* who worked in the mines in the nineteenth century (Owen, 86).

5.1.4 Each of the three systems surveyed (see below) used water draining from the Great Opencast. This was the most highly concentrated of all the waters to come from either Parys or Mona mine (Hope, 78), and accordingly the system developed at Dyffryn Coch became the most extensive on Mynydd Parys.

5.2 System 1.

5.2.1 The upper, or western-most, system of precipitation pits surveyed basically consists of features 4 to 72, with some additional channels to the east. They appear to form part of a very early system, already in existence by 1786, which served the Parys mine, and it is noticeable that the lay-out of the system is more complex and irregular, and the pits of differing sizes, when compared to the two systems to th east.

5.2.2 The water supply for this system was traced back to a channel running to the south of the Great Opencast to a point where the remains of a shaft and a building are visible at SH43979000. These probably represent the remains of the pump shaft on the edge of the pit marked on a map of 1856 by H. Dennis (probably Henry Dennis of Rhiwabon, the mining engineer) as "South Engine or Water Whimsey Shaft" (UWB General Collection 31584), a name which marks the change in uphaulage methods. Presumably it was originally powered by a horse-whim and, at some later stage, possibly already by 1815, was powered by a steam engine (Briggs, 78; Hope, 78, 166n).

5.2.3 The water entered the pits by a now-dry level (feature 04), which may be the tunnel marked on the Dennis map of 1856 as the 20-fathom Dyffryn Coch level. The probable water-flow has been reconstructed and is shown as clearly as it could be made out, on map 04. After passing through a series of precipitation pits, the water entered the oxchre pit (feature 71): from here it would have been passed out via arch 89, along channel 112 and (probably) eventually into lake 195.

5.3 **System 2.**

5.3.1 The water seems to have entered this system from a drainage tunnel (feature 73, and which is marked as early as 1786 (UWB General Collection 31603)) which emerges from under the present roadway to the north of the dam marking the end of the first system (feature 71), and from which copper-impregnated water still flows.

5.3.2 The pits are very different in character and layout to those in the first system, being more regular in size and shape. They have the appearance of having been planned and laid out at a single time, whereas those in the first system seem to been developed organically over a period of time.

5.3.3 Ochre pit 101 marks the eastern-most extent of this system, and it seems possible that water went from here to pit 130 (to the south of the next system), and again finally into lake 195.

5.4 **System 3.**

5.4.1 It appears that the bottom system was fed from a now collapsed level, below where the pile of dumping (feature 117) is, as water still seeps out of the ground near here, where the end of the tunnel mouth would have been.

5.4.2 From here an extensive and very regular set of pits and leats took the water eastwards, eventually to the large lake (195), which forms much of the southern boundary of the Mona mine. This is amuch more complex (and therefore later?) system than the second one, involving eight or nine different pits through water would have passed, and leading to the large lake rather than a formal ochre pit. The system is complicated even more by the presence of a series of side channels to the south (features 130 -36), by the now-ruined buildings (features 145-6) and higher pits (features 138-44) above its northern side, and by the complex of pits or tanks at its lower, eastern end (features 150-6) and at the western end of lake 195.

5.4.3 It is interesting that this part of the system is not marked on the 1839/1840 1", but is marked on the 1887 25", although it cannot be dated more exactly.

5.4.4 It does appear that we can see a chronological development from system 1 to system 3, although the later systems may well overlie earlier ones. It is possible that there was room for the construction of at least one more system, over the western end of lake 195, which was never needed, but this is purely conjectural.

5.5 **Vitriol works.**

5.5.1 There are few upstanding remains of the vitriol works (*y gwaith fudrol*). There are no visible buildings, although there are a few pits (features 162-6) and in addition there is a leaching pile (feature 162) consisting of a large pile of pink pyritic material: this is ferrous disulphide (an abundant waste material, presumably carted to the site from somewhere on the mountain) which has been burnt to produce haematite *etc.* (see above section 4.4) a process which may be represented

$$2FeS2+5 1/2O2 \rightarrow Fe2O3+4SO2+H2O+1/2O2 \rightarrow H2SO4.$$

5.6 **Summary.**

5.6.1 The documentary and survey work carried out as part of this project have served to demonstrate the basic working principles of three systems of precipitation pits, one of the principal means of obtaining copper ore on Mynydd Parys, along with a number of associated activities. As far as the authors are aware, this has been the first attempt to record, interpret and explain this particular type of industrial process in archaeological terms. It is felt that the work has thus enhanced the unique importance of Mynydd Parys in terms of industrial archaeology.

5.6.2 The precipitation pits and the ochre ponds constitute an integral part of an important industrial landscape which encompasses the whole mountain beyond the limits of the survey area. This survey has recorded and analysed a series of related elements in what was at one time the largest copper mine in the world, a site that has been exploited at various time from the bronze age until the present day, and has amply demonstrated the potential of the entire site for carrying out similar work.

5.6.3 Having said that, there is more work which could be undertaken on the features recorded by this survey if many of the outstanding problems are to be resolved. Principal amongst these are: dating (if only relative dating by detailed analysis of the construction and development of the various pits and channels): recovery and analysis of samples, more detailed analysis of the water-flow systems (based on levels), examination of the vitriol works, closer examination of the detail of the walls of ths pits to determine whether any phasing details can be observed *etc*.

5.6.4 Mynydd Parys stands alone as an industrial site within a British context. In historical terms, the value of the remains on Mynydd Parys is heightened by their connection with the Roe family of Macclesfield and with Thomas Williams "The Copper King". Its scale underlines its international importance, but equally the survival of low-cost, low-technology extraction and processing, making use of methods evolved centuries earlier in Europe establishes it as an important archaeological resource that can most appropriately be compared with the great centres of continental mining, such as the Harz mountains and Rio Tinto.

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6.3 Dr D Jenkins kindly examined the site of the vitriol works and supplied the chemical formula.

6.4 Leila Beggin kindly translated the eye-witness acount of Victor-Frere-Jean which appears in Appendix II.

6.5 The fieldwork was carried out by Dr. D. Rh. Gwyn, A. Shallcross and D. Thompson: the plans were drawn up by L. A. Dutton and A. Shallcross; and the report was written by Dr. D. Rh. Gwyn and D. Thompson.

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APPENDIX I

GAZETTEER

Gazetteer

01 Dam
Now partially collapsed, served to hold back water in higher active pit (outside survey area).

02 Arch
Brick archway through 01.

03 Building
Brick-built, rectangular building, function unknown. Possibly containing some form of sluice mechanism (now ruined), on northern edge of dam 01.

04 Arch
A channel (05) leads out from the mountain via this small stone archway in the corner of dam 01.

05 Channel
Stone-lined channel which emerges from 04: the top of it is now blocked, but it continues the length of pit system 06, into which it formerly fed, and finally empties into pit 07.

06 Pit
A large, rectangular, shallow pit fed by water from channel 05 although now dry. It is in fact a series of four pits, subdivided by raised areas.

07 Pit
A pit, similar to 06, and fed from its western end by channel 05: it too is sub-divided into four by raised areas.

08 Pit
Stone lined pit, not obviously part of the system.

09 Wall
Length of walling running between pits 07 and 11: to the south, there is a considerable drop down to the bottom of pit 11 and the next level of tanks.

10 Pit
Irregularly-shaped pit, similar to 08, a brick floor evident in places: like 08, not obviously part of the water-flow system.

11 Pit
Possibly a continuation of pit 10 though wider, with a raised area in between the two.

12 Channel
A short covered channel through the wall here leads from pit 07 through on to ledge 17 (the water would presumably have gone into pit 30, or, if the ledge formerly carried a wooden duct, elsewhere).

13 Wall
A substantial, brick-built wall which runs north-east - south-west along much of this system.

14 Wall
Similar in type and constriction to 13, this wall runs perpendicular to it and parallel to 15.

15 Wall
Similar in construction to 14 and running in the same direction.

16 Wall
Similar to and linking walls 14 and 15.

Walls 13, 14, 15 and 16 have the appearance of having been built at the same time: they were probably the last features to be constructed in this system, and their height (over 0.5m above might imply that they were built to cope with raised water levels in the intervening pits.

17 Ledge
Formed probably by the top of an earlier (now partially buried) wall, this feature appears to be a ledge at a level below wall 13 which runs east - west along the system.

18 Wall
Fairly massive retaining wall, lessening in height towards its southern end, holding up feature 19.

19 Ramp (putative)
Feature alongside the face of dam 01, presumably formerly serving as a ramp to allow carts access down to the pits 22, 24 *etc.*.

20 Wall
Small, well-built right-angle of wall at the base od dam 01 and ramp 19, which defines a pit (21) to its north-west.

21 Pit
Pit for receiving iron objects at the bottom of ramp 19 against the base of dam 01.

22 Pit
Pit formerly fed by water from pit 06, and feeding into pit 24: still water-filled.

23 Channel
Probable channel for water between pits 22 and 24.

24 Pit
Pit formerly fed from pit 22 via channel 23 at the base of dam 01. Still water-filled, with a series of possible raised sub-divisions (see descriptions for pits 06 and 07) running across it in an east - west direction.

25 Wall
Long, massive wall, over 2m high, which appears to delineate the edge of this system on the south side (but see also 26).

26 Pit (possible)
A level area above wall 25 but below the level of dam 01, now completely overgrown, may possibly formerly have been part of this water-flow system, either a pit or a drying floor of some sort.

27 Pit
A large water-filled pit, similar to 24 (which fed water in to it), again with possible raised areas running east - west.

28 Platform
A submerged platform is clearly visible at the southern end of pit 27: it has a brick floor and a deeper channel runs around its eastern end, possibly for water to flow out into pit 43.

29 Pit
A small, water-filled, pit whose northern half is shallower than its southern half due to a definite shelf which occupies the former. A small groove (30) is cut into the edge of this to allow water to flow over.

30 Channel
A small groove is cut into the edge of the shelf in pit 29 to allow water to flow over into the deeper end.

31 Wall
A short length of wall exists between pits 29 and 32.

32 Pit
A water-filled pit, similar to 29 but without a subdivision: its western side is not completely defined. This is the only pit in the area whose exit channel cannot readily be determined: it probably emptied in to pit 27.

33 Pit
Similar pit to 32, though its edge is less well-defined, again it is water-filled. There is a sluice opening in the southern end of the east wall. There is no obvious water channel leading into this pit, though it empties into 34.

34 Pit
Similar pit to 33, again water-filled, emptying into pit 49.

35 Features
There are a series raised areas which define the series of pits 33, 34, 36, 37, 38, 40, 44, 48 and 49. They are almost all now submerged and badly eroded (by water), but are quite definite.

36 Pit
A small rectangular, water-filled pit, fed by 37 and feeding 49.

37 Pit
Similar to 36, probably fed by 33 and feeding 36.

38 Pit
A larger, rectangular, water-filled pit, fed from pit 27 via sluice 39. It fed pit 40.

39 Sluice
Remains of a former sluice in wall 14 between pits 27 and 38.

40 Pit
Similar pit in size and shape to 38, which fed into it. Its southern end is partially obscured by heavy undergrowth.

41 Pit
Long, rectangular water-filled pit whose eastern end is obscured by undergrowth.

42 Wall
Substantial section of walling forming the south side of tank 41.

43 Pit (possible)
Possible former pit, trapezoidal in shape, now infilled and obscured by vegetation: it is at a higher level than the neighbouring pit 41. Much of it is obscured by dense undergrowth.

44 Pit
Small pit on the edge of the system which narrows at its eastern end: it is fed by a substantial channel (45) from pit 40, and feeds into pit 59, which is at a substantially lower level.

45 Channel
A substantial channel leading from pit 40 to pit 44, with the remains of a sluice at its eastern end.

46 Wall
A short stretch of wall of similar construction to 47 (and probably of one build with it), which juts out west from it between pits 44 and 48.

47 Wall
A large substantial wall forming the eastern end of pits 48 and 49. Immediately to the east of it there is a drop down to a level on which the next set of pits (58 and 59) is to be found.

48 Pit
A small, sub-square pit fed by a channel from 40. It feeds into pit 58 via a sluice (now blocked) in the bottom of wall 47.

49 Pit
A small, trapezoidal-shaped pit against wall 47, fed by channels from pits 34 and 36.

50 Pit
A small, irregular pit in a corner formed by a series of walls. This is a curious feature whose role in the system is unclear: it is fed by a channel (51) which emerges from under wall 13 and ledge 17, but it has no visible outlet.

51 Channel
The mouth of a channel with a wooden lintel which feeds into pit 50.

52 Pit
A long, rectangular pit, now overgrown and with edges partially obscured by vegetation, on the same level as pits 53 and 54, and lower than pit 10 and higher than pits 48, 49 and 58. Details are obscured but it was probably fed from either pit 10, or a from pit in the area now covered by modern dumping. It probably fed into pit 54 but this is unclear.

53 Pit
A small rectangular pit, similar to the adjacent pit 52 and largely obscured by vegetation.

54 Pit
A long rectangular pit, largely obscured by vegetation although the brick floor is visible in the centre. It appears to have been fed from pit 60, and probably fed into 58 which is on a lower level.

55 Pit
The remains of a possible pit whose detail has been completely obscured by vegetation.

56 Wall
A long, substantial wall, similar to, and probably one build with, wall 47, which defines the southern edge of pit 54.

57 Ledge
At the western end of pit 58 is a flat area, below the level of pit 48, through which runs the channel which feeds from the latter into the former.

58 Pit
A well-preserved, long, narrow, rectangular pit, linked to pit 59 by three cross-channels. It was fed by a series of pits including 48, 60, (probably) 54 and another pit (now destroyed) via channel 66.

59 Pit
A well-preserved, long, narrow, rectangular pit, linked to pit 58.

60 Pit
A large, square pit, on sloping ground on approximately the same level as 53 and 54 (into which it possibly feeds), whose northern edge is mostly buried by hillwash. It feeds via channel 61 into pit 58.

61 Channel
A channel forming the outlet from pit 60 to pit 58.

62 Wall
A substantial length of wall which forms the south side of pit 60 above pit 58. It is similar to wall 56, and was probably built at the same time.

63 Wall
A substantial length of retaining wall which supports pit 64.

64 Pit
Only the southern part of this pit is visible. It has been built up from the hill slope, and was probably fed from a source outside the survey area and which has since been destroyed.

65 Pit
A probable pit below 64 (though not obviously linked to it) and above pit 67.

66 Channel
The line of a putative channel which runs downhill above the side of pit 60 from an unknown source and feeds into pit 58. Its east side is defined by retaining wall 63, and its western side partially by the return of wall 62.

67 Pit
A small, irregularly shaped pit linked to pit 68 by a narrow channel: both are fed from pit 58. The retaining wall for putative channel 66 may explain the truncated western corner.

68 Pit
Irregular-shaped pit linked to 67, and fed from pit 58.

69 Wall
A short stretch of retaining wall above pit 70.

70 Pit
A putative pit, now completely overgrown, on the southern edge of the system.

71 Pit
An ochre pit, defined by a substantial wall on the south side, a dam (80) above the next system on the east above the next system, a retaining wall terraced into the hill slope on the north, and a dam holding up pits 67 and 68 on the west. It is fed from pit 68 through channel 72, and in turn it feeds into the next system (pits 84 and 88 and channel 112) via a series of sluices (85 and 89) in the dam wall.

72 Channel
Pit 68 feeds into pit 71 through channel 72.

73 Channel
Archway where channel emerges out from underground: stream (74) is still running.

74 Stream
Centre of stream which emerges from 73 and now flows over area to east.

75 Wall
Retaining wall forming part of dam above watercourse 74.

76 Wall
Retaining wall above watercourse 74 on its north side.

77 Wall
Long length of revetting wall now forming the edge of the modern track.

78 Wall
A curious section of high walling jutting out from below the dam partially across the course of stream 74. Possibly a pipe outlet of some sort.

79 Boundary marker
A square stone pillar, with a domed top, set into the ground with four, regular, flat faces: the north-east face has the letter A carved into it, and the south-west face has the N. It is possibly a boundary stone, although it is difficult to imagine (beyond A = Amlwch) what the letters stand for.

80 Dam
Well-built stone dam forming the east side of pit 71.

81 Channel
A stone 'edge' defining a shallow water-channel (82) to the west.

82 Channel
A putative water-channel coming from pipe outlet 78.

83 Wall
Wall defining the north-east side of pit 84.

84 Pit
Pit, now largely overgrown, fed from pit 71 via channel 85.

85 Channel
Water channel between pit 71 and pit 84, through dam 80.

86 Pit (putative)
A curious area whose function is difficult to determine. Possibly an overflow area between channel 82 and pits 88 and 91.

87 Edge
An apparent eastern edge to area 86.

88 Pit
Large rectangular pit, fed by channel 89 through the dam from pit 71: some indications of internal divisions (see pits 6 and 7).

89 Arch
Arch in the wall of dam 80 marks the place where a water channel emerges.

90 Channels
A series of five channels allowing water to flow from pit 88 to pit 91.

91 Pit
Large rectangular pit, subdivided by brick causeways, fed from pit 88 and feeds into pits 95 and 96.

92 Channel
Water channel between pits 91 and 96.

93 Channel
Water channel between pits 91 and 95.

94 Channel
Water channel between pits 95 and 96.

95 Pit
Similar to pits 88 and 91 only shorter: it appears to have three sub-divisions.

96 Pit
Large rectangular pit, now partly overgrown and whose southern edge was not defined.

97 Channel
Long, curving water channel draining from pit 96 and emptying into large ochre pit 101.

98 Wall
A stretch of partly-buried wall which defines the north side of channel 97.

99 Pit
Rectangular pit, similar to pit 95 and fed from it via three channels.

100 Wall
Curving section of wall which forms the rear of pit 101.

101 Pit
Vast ochre pit, still water-filled.

102 Channel
Putative channel emerging from underground at its northern end, linking with channel 97 and emptying into pit 101.

103 Penstock
Putative penstock, probably fed from channel 108.

104 Channel
Slight remains of a possible channel, now largely overgrown, leading down the hill slope: it is defined by a depression with a bank on its north side, and possibly took water from the roadway area to pits 95 and 99.

105 Wall
A short length of wall whose function is uncertain.

106 Wall
A length of retaining wall, probably a continuation of 76 (now partly overgrown).

107 Edge
Stone edging for possible former channel.

108 Channel
A channel running along the contour of the hill above pit 101: it probably empties in to penstock 103.

109 Dam
Large dam forming the eastern, downhill side of pit 101.

110 Fence
Modern post and wire fence, apparently running along the southern edge of pit 101.

111 Pit
Elongated pit, now heavily overgrown, fed by water from channel 112 at its eastern end.

112 Channel
Long stretch of water channel probably originally emerging from dam 80 (via arch 89), and thus taking water from pit 71 to pit 111.

113 Sluice
Outlet allowing water to pass from channel 112 to pit 111.

114 Wall
Wall holding up edge of modern track which passes over dam 109 to Trysglwyn farm.

115 Channel
Water channel running along the base of dam 109 and draining into pit 116. Its source is lost (see 117).

116 Pit
Long rectangular pit fed from channel 115 and feeding into pits 118 and 119.

117 Dumping
Area of modern dumping, probably obscuring the source of water for channel 115.

118 Pit
Short rectangular pit, fed from pit 116 and into pit 121.

119 Pit
Short rectangular pit, fed from pit 116 and into pit 121.

120 Pit
Short rectangular pit, fed from pit 116 and into pit 121.

121 Pit
Short rectangular pit, fed from pit 116 and into pit 121.

122 Pit
Small pit, may possibly be part of pit 121.

123 Pit
Large, rectangular pit, fed from pits 120 and 121, and feeding into pits 124 and 125. There is a small pit, possibly part of this one, to the south (see also pit 122).

124 Pit
Rectangular pit, fed from pit 123 and feeds into pit 126.

125 Pit
Rectangular pit, fed from pit 123 and into pit 126.

126 Pit
Large rectangular pit whose southern end is overgrown and obscured. It is fed from pits 124 and 125, and feeds into pit 127.

127 Pit
Narrow rectangular pit fed from pit 126 and into pit 128. There may be another parallel pit to the south of this pit, but the area is completely overgrown.

128 Pit
Rectangular pit, fed from pit 127 and feeds out apparently below channel 148 via channel 151.

129 Pit
Long rectangular pit, fed from pits 132 and 130 and feeds into pit 128 and probably out via channel 153.

130 Pit
Large, irregular-shaped pit on the southern edge of the system and at a heigher than pits 116 - 129. Water feeds into it at the western end through channel 131, probably from pit 111 or 101 although this is not clear. It feeds into pit 129, possibly partially via pit 132.

131 Channel
Water channel (partly underground) feeding into pit 131, from either pit 101 or 111.

132 Pit
Narrow rectangular pit, possibly fed by pit 130 though the linking channel 133) is not now visible.

133 Channel
Putative channel between pits 130 and 132, not now visible.

134 Wall
Substantial stone wall retaining pit 130, now topped by modern fence.

135 Arch
Outlet in wall 134 through which passes channel 137.

136 Wall
A section of retaining which rises in height from its east to its western end. It probably formed a ramp giving access between the different levels of pit 130 and dam 109, and pits 116 - 129.

137 Channel
Water channel which allows water to flow from pit 130 into pit 129.

138 Wall
Retaining wall, now partly obscured by modern disturbance, above pits 139 and 142.

139 Pit
Rectangular pit, above the level of pits 116 - 129. Its role in the system is uncertain, as it has no obvious feeder although it has an exit channel at its south-eastern corner.

140 Wall
Large retaining wall with a return apparently to support putative pit 141.

141 Pit
Putative pit above the level both of pits 139, and pits 142 - 144. It has no obvious channel feeding into it, although it appears to feed into pit 144 at its eastern end.

142 Pit
Small pit, whose edges cannot be fully traced: it probably feeds into pit 143, but no channel is visible, and its water source is completely unknown, although it may be connected with channel 115.

143 Pit
Small pit, similar to 142 and probably fed from it: in turn, it probably feeds into pit 144.

144 Pit
Small pit similar to pit 143 and probably fed from it and from pit 141: in turn it feeds into pit 125.

145 Structure
There area a number of large sections of walling just below the modern track in this area, suggesting the presence of a former structure, probably a building, whose date and function are not known.

146 Structure
There are the possible remains of a collapsed adit within the area of structure 145.

> **N.B.** This area of the site (features 138 to 146) is complex and very fragmentary and cannot readily be explained. It lies outside the main water system, both physically and operationally, as represented here by pits 116 - 129.

147 Channel/Leat
A water channel runs along the northern side of the system for over 200m. It may be a continuation of channel 108 to the west.

148 Channel
A deep slot cuts right across the water-flow system here: it is most probably a channel of some sort, but ist precise function is difficult to determine.

149 Pit
Well-defined pit which appears to be at a slightly higher level than the surrounding area: it has no visible means of water supply, but there is an exit channel in the south-eastern corner.

150 Pit
Small pit below the level of adjacent pit 149, which is fed by a stream (not actually a channel as such) from pit 128 via channel 151. It appears to feed eventually into pit 158.

151 Channel
Short, narrow section of channel which takes water from pit 128 under (or through?) channel 148 before the flow widens into a small stream which flows into pit 150.

152 Channel
Fairly ill-defined channel which appears to take water around pit 149 and into pit 158.

153 Channel
Short, narrow section of channel which takes water probably from pit 129, under (or through?) channel 148 before the flow widens into a less well-defined channel (152).

154 Pit
Narrow rectangular pit, heavily overgrown, probably fed from pit 155.

155 Pit
Small pit, heavily overgrown and whose detail is obscured, below channel 148.

156 Pit(s)
An area now heavily overgrown and poorly defined, which contains the probable remains of a pit or pits.

157 Pit
Well-defined, long rectangular pit at the western end of a lagoon: it is fed by a stream from a now-blocked adit to the north, and it probably feeds out into the lagoon at the south-eastern corner. Its role in the water-flow system is uncertain.

158 Pit
Long rectangular pit, similar in size and location to pit 157 but less well-defined. It is fed from channel 152, and probably feeds directly into the lagoon in whose western end it is situated, but it was largely underwater and was not investigated further.

159 Pit
Possible pit by the side of the track whose detail is too vague to allow further definition.

160 Leaching pile
A pile of vivid, pink-coloured rock near the site of the former vitriol works. It probably represents the remains of waste which has been carted over from the mine workings, and some process (possibly baking) connected with the works has been applied to it (see also feature 162).

161 Pit
The remains of a small pit, now heavily overgrown. A number of walls appear to exist in the dense undergrowth around it.

162 Leaching pile
See pit 160.

163 Pit
Remains of a rectangular pit, now heavily overgrown.

164 Pit
Remains of an elongated pit, now heavily overgrown, similar to pit 163.

165 Pit
Remains of an elongated pit, now heavily overgrown, similar to pit 163 although slightly larger.

166 Pit
The remains of a feature, probably a pit, now heavily overgrown.

> **N.B.** The area in which features 159 to 166 are located was initially recorded by S Boyle in February. When it was re-visited in June the undergrowth was over head height and details of the features were impossible to discern.

167 Overflow
A feature leads off downhill from channel/leat 147 towards the lagoon. It is probably an overflow.

168 Trackway
A short section of former trackway lead from the existing track across channel 147, down towards the edge of the lagoon.

169 Structure
The remains of three walls forming a small irregular structure whose function is unknown.

170 Channel
A short section of channel which appears to have taken water from channel/leat 147 into pit 171. There are a number of channels in this area (172 and 173) whose precise functions are uncertain.

171 Pit
Large, irregular-shaped pit constructed out into the northern side of the lagoon. It is formed by a large wall (174) on the 'downhill' side, and its rear is against th natural hill-slope around which runs a trackway, 176, still in use. It is fed by channel 170, which probably leads fron channel/leat 147, and it feeds into both pit 171a (adjacent) and directly out into the lagoon at its southern corner.

171a Pit
Large, rectangular pit adjacent, and similar in construction, to pit 170 but obviously later (there is a butt joint between the sections of walling in the south-western corner. It also feeds out directly out into the lagoon.

> It is probable that these were both precipitation pits, but there relationship to the rest of the systems is unclear and they have formed part of a system which lies outside the survey area to the north, further up the mountain.

172 Channel
A short length of water channel between channel/leat 147 and pit 171. Its precise function is uncertain.

173 Water channel
A short length of water channel between channel/leat 147 and pit 171. Its precise function is uncertain.

174 Dam/wall
A substantial stone wall which in effect forms a long, three-sided dam jutting out into the lagoon and forming pit 171.

175 Sluice
A sluice gate in the southern corner of wall 174 which allows water to flow out of pit 171 into the lagoon.

176 Track
A trackway, still in use, which leads down from the main track and around the contour north of pits 171 and 171a. It eventually crosses over the dam (178) forming the east end of the lagoon.

177 Sluice
A sluice gate in the south-eastern corner of pit 171a which allows water to flow into the lagoon.

178 Dam
A substantial stone wall forming the end of the lagoon: a sluice exists near the centre to allow water to pass through to the lower lake.

179 Channel
A water channel apparently running downhill, whose precise function is uncertain.

180 Pit
A possible pit, whose western end is lost in dense undergrowth, and whose southern side sits on, and is later than, channel/leat 147. There may be a channel feeding in to its north-west corner.

181 Pit
A possible pit apparently overlying channel/leat 147, whose northern and southern walls have the appearance of being revetting walls.

182 Track
A short length of trackway leading down the hillside: its full length cannot be traced and its function remains uncertain.

183 Pit
The remains of a probable pit built against the southern side of channel/leat 147 in the corner of the lake (now dry). There are the remains of a possible mound, a small enclosure and two short sections of walling at the western end, and the dense undergrowth obscures much of the finer detail.

184 Wall
Long length of substantial retaining wall running along the contour of the hill below the eastern end of channel/leat 147 and, in part at least, supporting it.

185 Channel
A substantial water channel which appears to start outside the survey area to the north in connection with another system, and emerges into the area via a substantial gap cut into the bedrock at its eastern end, and runs westwards following the contour of the hill. At its western end it appears to finish and probably empties into the lake.

186 Wall
A length of retaining wall associated with channel 185.

187 Wall
A series of straight and curvilinear stone walls, now submerged and therefore not investigated fully, which appear to form an edge to a deeper part of the lake (to the east of it). The straight edges near the western end slope down towards the middle of the lake to form what appears to be a sort of slipway.

188 Sluice
A sluice for water to pass into the lake at the bottom of the western end of dam 193.

189 Sluice
A sluice for water to pass into the lake at the bottom of the eastern end of dam 193.

190 Sluice
A sluice to allow water to drain out of the lake in the bottom corner between dams 191 and 192. It is now much tumbled down.

191 Dam
Massive dam, c. 5m high, forming the bottom of the lake and therefore the bottom end of the series of systems, although further pits and features are in evidence 'outside' it. The dam has a sloping profile and carries a further channel along its top.

192 Dam
Massive dam similar to 191, again up to c. 5m high at its eastern end. It is interesting that it finishes well short of the apparent top, western, end of the lake.

193 Dam
Smaller than 191 and 192, this dam forms the northern side of the bottom lake and contains two sluice gates to allow water in from other pits.

194 Ridges
A series of ridges run north-south across lake 195. The ridges stand slightly proud of the lake bottom here, but do not appear to have any build: when prodded by a ranging they offered slightly more resistance than the surrounding areas, but no buried solid objects were encountered. There is no obvious explanation other than they were for some reason left like this by clearance of the ochre from the pit (still over 1m deep).

195 Lake
A vast lake which forms the bottom part of the series of waterflow systems in the valley. It stretches from pits 157 and 158 at the western (top) end, to dam 191 at the east. The western end is overgrown with bog-cotton *etc.*, and the east end is still water-filled. A short section near the eastern end is 'dry' and contains a series of ridges (see 194). In the area of the ridges (194) the sediment is just over 1m deep.

APPENDIX II

EYE-WITNESS ACCOUNT OF THE WORKING AT MYNYDD PARYS

Victor-Frère-Jean, Esquisse Géologique de l'île d'Anglesey, *Annales des Mines*, published in 1826 observed

"les eaux de cette mine sont très-peu abondantes; une seule machine à feu, de la force de 6 chevaux, placée à quelque distance de la grande ouverture, suffit pour les extraire; elles sont très-chargées de sulfates de cuivre et de fer; elles servent à laver le minerai concassé préablement, et de là elles se rendent dans plusiers vastes bassins, où on precipite le cuivre avec des ferailles et des débris de fonte. Les eaux passent d'un réservoir à l'autre jusqu'à trois ou quatre fois, et après avoir subi le même nombre de précipitations, elles se rendent dans la mer. Lorsque ces eaux ont été en contact pendant quelques mois avec la fonte, elles prennent une couleur jaune et déposent de l'ocre, qu'on receuille à différentes epoques: ces eaux sont continuellement remuées avec des racloires pour renouveler les contacts.

Le minerai, au sortir de la mine, est exposé à l'action d'un courant d'eau qui nettoie parfaitement sa surface; en sorte que'il est facile de séparer les morceaux de gangue du minerai pur; ce sont les petites grilles de fer suspendues, sur lesquelles tombe continuellement un courant d'eau; il suffit, lorsque les pyrites de cuivre y sont placées, de les remuer de temps en temps pour que toutes leurs surfaces soient exposées à l'action de ce liquide. Après ce lavage, le minerai est concassé avec des marteaux, en fragments de la grosseur d'une noix; on occupe à ce travail, dans cette exploitation comme dans toutes les autres, les femmes et les enfants (233-4).

"waters of this mine are not abundant; a single six horse-power steam engine, positioned at some distance from the main opening suffices to extract them; they are much charged with copper and iron sulphates; they are employed to wash the ore, previously broken up, and from there they flow into a number of vast basins, where the copper is precipitated with iron and cast iron debris. The waters pass from one reservoir to another some three or four times and after having been subjected to the same number of precipitations they flow into the sea. When these waters have been in contact with the cast iron for a few months they take on a yellow colour and leave an ochre deposit which is collected at different periods. These waters are continually stirred with scrapers to enable contact to be renewed.

The ore, when it emerges from the mine, is subjected to a current of water which perfectly cleans its surface so that separating the pieces of gangue from the pure ore is a simple matter, thanks to the small suspended iron grills on which a constant flow of water falls. Once the copper pyrities are placed upon them, it suffices to agitate them from time to time for all the surfaces to be exposed to the action of the liquid. After washing, the ore is broken up with hammers into fragments the size of a walnut. In this, as in all other exploitations, women and children are employed in this work" (233-4).