Parys Mountain, Anglesey

Heritage Management Plan 2014

Cadw
Llywodraeth Cymru
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Ymddiriedolaeth Archaeolegol Gwynedd
Gwynedd Archaeological Trust

Parys Mountain, Amlwch, Anglesey

Heritage Management Plan 2014

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1. INTRODUCTION

1.1 Scope of the Plan

This Heritage Management Plan, undertaken by Gwynedd Archaeological Trust (GAT) funded by grant aid from Cadw, and undertaken in partnership with Amlwch Industrial Heritage Trust is concerned with the heritage of Parys Mountain, an area of copper mining located in the north of Anglesey centred on NGR SH44319051. The plan relates primarily to the surface remains, and does not take full account of the underground remains. The surface mining remains occupy an area of some 2 square kilometres.

The plan draws on an updated archaeological survey of Parys Mountain undertaken in 2014 (Gwynedd Archaeological Trust 2014), which in turn is an update of the assessment survey undertaken in 1998 (GAT 1998, Report 292). In addition this plan also updates a Conservation Management Plan undertaken in 2005 (Gifford and Partners 2005), both reports undertaken on behalf of Cadw and Amlwch Industrial Heritage Trust (AIHT). The 2005 plan related to a wider geographical area which included both Amlwch and Porth Amlwch in addition to Parys Mountain. It was also wider in theme, including both geology and ecology in its remit. This plan is limited to the archaeology of Parys Mountain and Dyffryn Adda, and is being undertaken in the light of recent consolidation and conservation works undertaken on the mountain by AIHT with HLF/Cadw/Council funding, and will incorporate the results of a number of recent surveys (see 1.3 below).

The plan will seek to:

- Further our understanding of the archaeology of the surface remains;
- Assess the significance of the above ground features and re-assess the significance of the site as a whole;
- Identify those issues which surround the management of the site;
- Identify policies which seek to address those issues.

Acknowledgments

The Trust gratefully acknowledges the help of David Jenkins (AIHT), Ian Halfpenny (Cadw), and David Gwyn (Govannon Consultancy).

1.2 Ownership and site management

The eastern half of the mountain is owned by the Most Hon. the Marquess of Anglesey; the western half by AMplc, though a royalty is payable to the Marquess and Sir Paul Neave, who formerly owned the site in moiety. Lord Anglesey's properties (the Plas Newydd Estate) are managed by Jones Peckover, Land Agents, 129 High Street, Bangor, Gwynedd.

AMplc have a surface lease and a mineral lease of the eastern half until the year 2054. AMPlc also has a planning consent granted by Gwynedd County Council in May 1986 (No 1/11/C/79) for the exploitation of zinc, copper and lead sulphide resources, chiefly in the western area. No archaeological conditions were attached to the permission. A further application was submitted by AMplc to Gwynedd County Council in February 1991 (No 1/11/c/77a) to

William Havell, Paris Mountain Copper Mine, c. 1803. Williamson Art Gallery and Museum

extend the tailings disposal area to the south of the mountain, however it was withdrawn.

Amlwch Industrial Heritage Trust was established in 1997 as a charity and company limited by guarantee. Its remit is to conserve the heritage of Amlwch Port and Parys Mountain for future generations to enjoy, and to support historical and scientific research. It has an under-lease from AMplc on the surface of the mountain.

1.3 Recent developments

1.3.1 Dewatering of mines in 2003

Sometime between the 1800 and 1815 a joint drainage level (linking the Parys and Mona mines) was dug at the Parys 45fm level to exit on the north side of the mountain at Dyffryn Adda. This adit fed the precipitation ponds at Dyffryn Adda which remained in use until the 1950's. In the 20th century a dam was inserted in the adit with valves to impound the water and control the flow to the pits. Following closure of the pits the valves were closed and the water rose behind the dam, forcing it to flow out southwards from Mona Adit into the Afon Goch South, which became highly polluted. In 2002 the Parys Underground Group (PUG), who had access to the underground workings, raised awareness with the Environment Agency and Anglesey County Council of the dangers which would result should the dam fail, as had happened elsewhere in the UK. In 2003 the water above the 45fm (Parys mine) level behind the dam was pumped out via the Gardd Daniel shaft, and the dam removed. The majority of the mine drainage now runs through this adit and into the sea, which has improved the water quality of the Afon Goch South. Though these works had minimal impact on the surface remains, they allowed access to many areas of previously unavailable underground workings. Exploration of these levels has led to the identification of potential blockages to this adit which might have further impact on underground remains and on possible surface flooding in the future (Jenkins et al, 2006).

1.3.2 Works at Henwaith Precipitation Ponds, 2009-10

In 2009 Isle of Anglesey County Council put in place remediation works to prevent contaminants blowing from the Henwaith precipitation pits on to the nearby property of Henwaith. The works involved a combination of seeding the western pits with a vegetation mix to consolidate the ochre, and re-watering the eastern pits to keep the ochre damp and hence stop it blowing off-site. An archaeological watching brief was undertaken during these works (GAT 2011, Report 914).

1.3.3 Works funded by HLF grant and match funding

In 2010 an HLF grant and match funding (by Cadw and other organisations) allowed several heritage enhancements to be carried out for AIHT (Jenkins 2014). These are briefly described below.

<u>The summit windmill (PRN 3497; SAM An 111)</u>
The windmill is one the most prominent features on the mountain. It was built in 1878, to supplement two horizontal steam engines pumping water from the 85fm level to the 45fm joint drainage level in the Cairns shaft via oscillating flat rods. The aim of the 2010 works was to conserve the tower and convert it to a wet weather shelter for use with the heritage trail. The jagged top of the tower was retained but stabilized by pinning and repointing. Similar techniques were used on the existing door and window openings. The shelter was provided by excavation of the interior basement of the windmill and the re-instatement of two floors with heavy oak beams and flooring. A part of the flooring was left free for illumination from above. The archaeology was monitored by Tim Morgan (Morgan 2013), and the architects were Garner-Southall. The sheltered space now houses displays and a map of the mountain and underground mine workings.

<u>The heritage trail, 'arete' and other features</u>
The heritage trail was first established in the 1990's, but an unofficial route between the two opencasts was regularly used as a shorter version of the longer trail; this involved crossing between the two opencasts with steep drops on either side. A walkway across the ridge has therefore been established by AIHT, comprising a buried concrete platform supporting a path with oak railings on both sides and stainless steel fittings. In the process of construction a stone-lined drainage channel was exposed (and recorded by Tim Morgan) – from its location this must date from the pre-opencast stage of mining. The trail has been marked by the insertion of eleven new trail markers and a new leaflet is being produced for 2014. An Ipad App has also been developed which introduces and describes sites at each of the waymarkers. Close to the start of the trail sampling facilities were constructed at a pool which allows safe access to copper-rich acidic water where the acid chemistry of the mountain and the process of precipitation of copper by iron can be readily demonstrated.

<u>Pearl Engine House and Chimney</u>
This engine house was first built in 1819 to pump water from the 95fm Pearl shaft, and it continued

working, albeit with a new engine installed in 1859, into the early 20th century. The distinctive chimney alongside the engine house fell during a gale in 1986. The intention had been to rebuild the chimney only, however it became apparent during the works that the engine house had also become unstable, and further grant aid was made available by Cadw to stabilise and re-roof the structure. The boiler house was excavated out and the original stone from the chimney set on one side. The chimney was rebuilt, and the boiler house filled back in to protect it. Tim Morgan recorded the archaeology during the works (Morgan 2013).

Display of mining heritage in the copper bins
A new display and information centre was established in the Copper Bins at Porth Amlwch. This pulls together much of the disparate information about the mountain, the subsidiary industries and the port.

Survey of scheduled features
A survey of the two opencasts, the Central Precipitation Ponds and the Mona kilns was undertaken by Gwynedd Archaeological Trust (GAT 2014, Report 1198). These complimented a number of other surveys already undertaken on the mountain of non-scheduled sites (GAT 2009, 2010).

1.4 Existing site designations

1.4.1 Landscape
Parys Mountain lies within the Amlwch and Mynydd Parys Landscape of Outstanding Historic Interest in Wales (Cadw et al, 1998, 72; HLW (Gw) 1).
1.4.2 Scheduled Ancient Monuments
There are five scheduled areas on Parys Mountain, namely:

Parys Mountain Windmill (An 111A; PRN 3497)
Pearl Engine House (An 111B; PRN 3499)
Hillside precipitation pits (An 111C; PRN 3498)
The Great Opencast (An 111D; PRN 3496)
Mona Mine Kilns and Sublimation Chambers (An 136; PRN 11495)

To the north of the mountain lie the Dyffryn Adda precipitation ponds and furnace scheduled as: Dyffryn Adda Copper Furnace and Precipation Ponds (An 135; PRN 6789).

1.4.3 Listed Buildings
Two structures within the study area are listed; both are also scheduled ancient monuments:
Parys Mountain Windmill, Listed Grade II, Ref 5425.
Pearl Engine House, Listed Grade II, Ref 24458.

1.4.4 Sites of Special Scientific Interest

The Mynydd Parys Site of Special Scientific Interest includes a number of areas of particular interest for

Pearl engine house under restoration with the rebuilt chimney alongside

2. SOURCES OF INFORMATION

A bibliography of sources up to 1998 is included in the Archaeological Assessment of that year (GAT 1998, Report 292). The current report includes an updated version of that bibliography, though it does not include the Mining Journal references nor the Newspaper references listed in the 1998 report, which remain unaltered.

The following new surveys (all unpublished) have added to our knowledge and understanding of the site, and the results, where possible, incorporated into this study:

- Gifford and Partners, 2005 Amlwch Copper Kingdom Conservation Management Plan.
- Gwynedd Archaeological Trust, 2009 Industrial Recording 2008-9 Parys Mountain, Report 788 (includes surveys of Parys Mine calcining kilns, Parys Mine yard, Mona Mine yard, Mona Calciner).
- Gwynedd Archaeological Trust 2010, Industrial Recording 2009-10 Parys Mountain, Report 859 (includes surveys of Henwaith Precipitation Pits, the windmill, Pearl Engine House).
- Gwynedd Archaeological Trust 2011, Henwaith Precipitation Pits, Mynydd Parys, Report 914 (undertaken in advance of works to contain the contaminated spoil lying within the pits).
- Gwynedd Archaeological Trust 2012, Historic Landscape Characterisation: Amlwch, Report 782 (a characterisation of the historic landscape, which includes Amlwch and Porth Amlwch).
- Gwynedd Archaeological Trust 2013, Updated site assessment of Parys Mountain (an updated site assessment and location of the surface features on the mountain – this updated the feature report carried out as part of the 1998 survey).
- Gwynedd Archaeological Trust 2014, Archaeological Survey of Scheduled Ancient Monuments (a survey of three scheduled sites, namely the Hillside Precipitation Pits, the Great Opencast, the Mona Mine kilns and sublimation chambers).
- Jenkins, D. A., 2006 Excavation of the Dyffryn Goch Adit: Great Opencast, Mynydd Parys, Amlwch, Parys Underground Group.
- Jenkins, D. A., Burroughs, O., Wagstaff, D., 2006 Report on underground drainage in the joint level, Mynydd Parys, Parys Underground Group.
- Morgan, T., 2013 Report on excavations at the Windmill, Parys Mountain
- Morgan, T., 2013 Report on excavations at Pearl Engine House
- Morgan, T., 2013 Dyffryn Adda Reveratory Furnace

A number of secondary sources have appeared in the intervening years. The following are of particular relevance:

- Bennett, J. S., and Williams, C. J., 2000 'Pearl Engine-house, Mona Mine, Parys Mountain', Transactions of the Anglesey Antiquarian Society, 39-60.
- Cradock, P., 1995 Early Metal Mining and Pro-

Parys Mountain Copper Mines 1815, H Hughes (National Monuments Record, C8236)

duction, Edinburgh University Press.
- Gwyn, D., 2006 Gwynedd: Inheriting a Revolution, Phillimore.
- Lord, P., 1998 The Visual Culture of Wales: Industrial Society, University of Wales Press, Cardiff.
- Rothwell, N. (trans and ed), 2007 Parys Mountain and the Lentin Letters, Amlwch Industrial Heritage Trust.
- Smith, D. Bentley, 2005 A Georgian Gent & Co: The life and times of Charles Roe, Landmark Publishing, Ashbourne.

Some additional new evidence has come to light regarding the early maps. The two Bangor University maps (BU Bangor 31602, 31603) used to support much of the evidence in the 1998 report are both copies made by E. Cockshutt in 1967 of plans described as 'in the possession of J. R. Harris'. The originals are now in the National Monuments Record (Ref's C8235 and C8236).

A British Library map (described in the 1998 report as 'copy in the possession of Bryan Hope') was dated from internal evidence to 1815-19. The full reference is 'Cartographic Items Maps 6135.(1.) Lithographic Print of the Parys Mountain, shewing the position of the Anglesey Copper Mines, J. Briggs, 1824'.

Another 'new' find has been the 1792 map by J. Corris housed in the National Library of Wales (NLW Maps 92), which clearly shows the boundary between the Parys Mine and Cerrig y Bleiddiau mine.

A full list of known paintings has been added to the bibliography. The principal artists are John 'Warwick' Smith, Julius Ceasar Ibbetson, Edward Pugh, William Havell and Warrington Smyth. These are discussed in greater detail below.

No new fieldwork was undertaken for this study, though site visits were made in 2013 in order to check specific features or views. The updated site assessment, undertaken in 2012, has been used extensively, and features and sites are referenced by the Primary Reference Number (PRN) of the Historic Environment Record (HER) held by Gwynedd Archaeological Trust.

Map of Cerrig y Bleiddiau mine, 1784-6 (National Monuments Record, C8235)

3. LOCATION AND LANDSCAPE

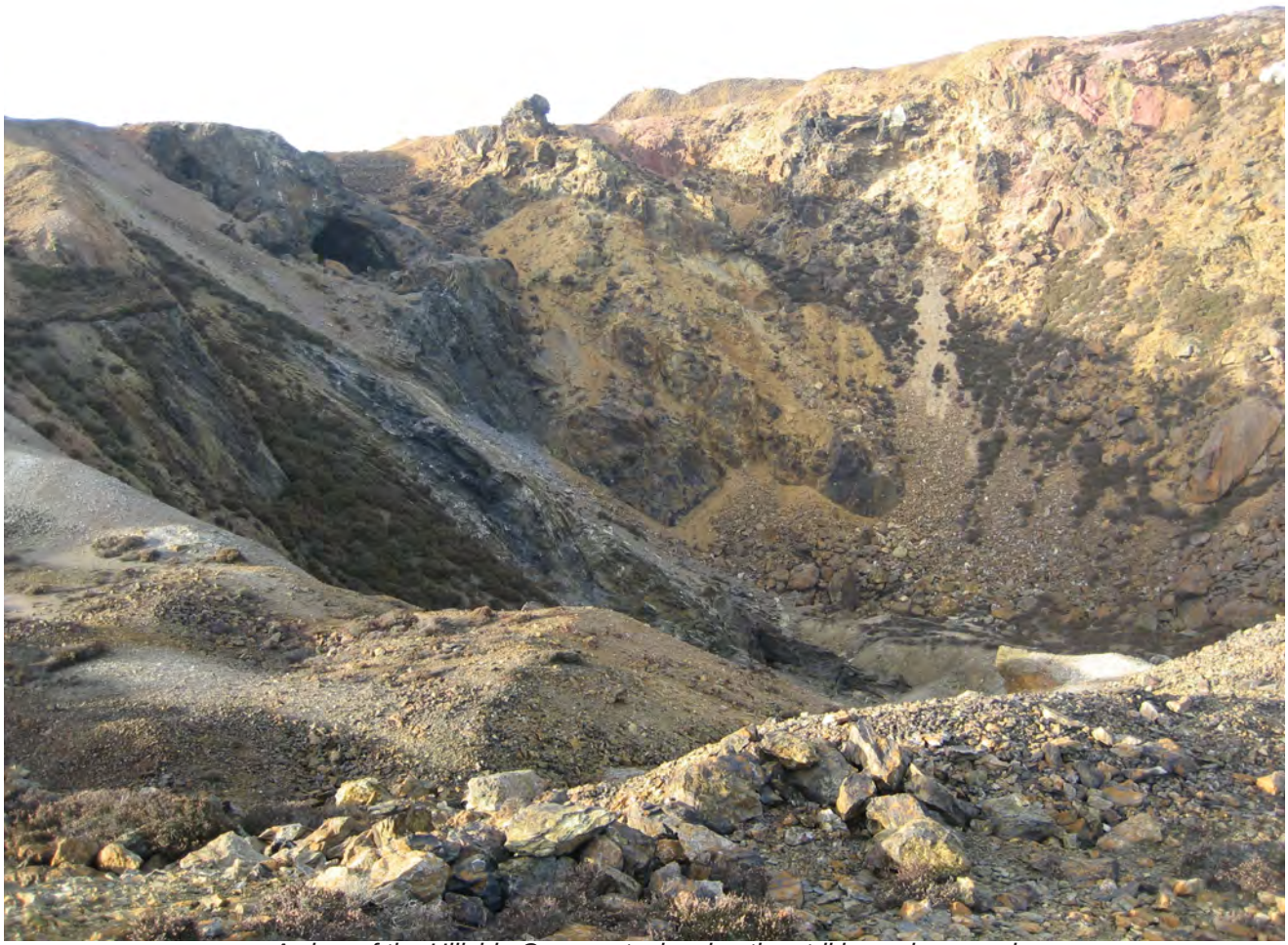
3.1 Location

Parys Mountain is located towards the north-east corner of Anglesey, centred on NGR SH443950. It is formed from a low ridge of outcropping rock some 2.2Km long SW-NE and 1.1Km wide SE-NW. It rises to a height of 147m, so qualifies as a mountain in name only. It lies within the medieval parish of Amlwch, and was formerly known as Mynydd Trysglwyn, after the medieval township with which it was associated. The farms of Trysglwyn Fawr and Trysglwyn Isaf lie on the south-western slopes below the mountain. To the north is the town of Amlwch and the harbour and settlement of Porth Amlwch, the two settlements contiguous. These are key elements within the wider landscape, and although they do not form part of this updated review, their role is considered in the original CMP (Gifford and Partners 2005). Also linked in medieval and early post-medieval times is the harbour at Dulas, 3.5Km to the south-west, used when contrary winds did not allow access to the narrow creek at Porth Amlwch. The harbour at Dulas is linked by a road running through Nebo and past the parish church of Llanwenllwyfo.

3.2 Landscape

Parys Mountain lies within the designated Amlwch and Mynydd Parys Mountain Landscape of Outstanding Historic Interest (HLW (Gw) 1) (Cadw et al 1988, 70-2). The landscape is described as '*an unparalleled, internationally important and visually highly striking landscape situated on Mynydd Parys in north-east Anglesey, comprising huge, mainly hand-dug opencast, 18th to 19th centuries copper mines and waste tips, with an extensive attendant complex of processing features and structures superimposed on earlier workings dating from the prehistoric and possibly Roman and medieval periods. The area also includes the remains of an associated transport system, settlements, Amlwch town, port and processing works*' (Cadw et al, 1988, 70-2).

A characterisation study of the area was undertaken in 2009 (GAT 2009, Report 782). Of the historic character areas identified, the primary mining area of the mountain formed one area (09) and the surrounding and outlying precipitation and ochre ponds another (08). The latter include the southern, Dyf-



A view of the Hillside Opencast, showing the striking colours and distinctive landscape of the mines

fryn Coch, precipitation ponds, and also the important remains at Dyffryn Adda (PRN 6789; SAM An 135) which lie part way between the mountain and Amlwch.

The key historic landscape characteristics of the mountain are described as follows:
The area is defined by the two great quarries near the summit of the ridge, which date from the closing years of the eighteenth century, and result from a policy of deliberately collapsing the underground workings opened since 1768. The need to follow the veins deeper underground led to the construction of the two most prominent standing buildings on the site, both of which operated underground pumps. The engine-house near the north-eastern limit of the site (SH 447 907) dates from 1819, and is believed to be the oldest surviving example in Wales to be built for a Cornish beam engine. The windmill tower at the summit of the mountain was installed in 1878 as an auxiliary to an adjacent steam pump engine, and is the single most prominent landmark on the mountain, visible over a considerable distance. No machinery survives in either structure. Other surviving buildings on the mountain are the offices of the two companies which operated the mine in the eighteenth and early nineteenth century. The quadrangular Mona Mine yard was in existence by 1786. Now extremely dilapidated, it once contained a smithy, lime-store, wagon shed, furnace, carpenter's shops, assay office, stables, a turnery and a place for the bier. Of the Parys Mine yard even less remains, but it seems to have been laid out in a similar way.
The sites of calcining kilns are also evident at a number of locations, visible as vivid pink craters, the condensation chambers as two parallel stone walls a few feet apart, in between which is a profuse growth of heather.
Underground workings are accessible at several points, though known shaft-sites were capped in the 1980s.
*The mines include the Mynydd Parys SSSI, split up into fourteen discrete locations, and several Scheduled Ancient Monuments, including the Great Opencast, the windmill and the Pearl engine house. (*GAT 2009, Report 782, 50*).*

The key visual characteristics are therefore defined as the Great and Hillside opencast quarries, the Pearl Engine house, the windmill, the mine offices, and the calcining kilns. Not mentioned, but of equal significance, are the chequerboard precipitation pits of which there are three significant sets on the mountain and another at Dyffryn Adda. These are unique within the UK, and highly visible. Their distinctive visual layout is also not mentioned in Area 08, where

Precipitation pits, unique to Parys Mountain within the UK, are a major landscape feature.

greater attention is drawn to the large ochre ponds. These also form a significant feature of the southern Dyffryn Coch pit system, and the eastern Henwaith system.

Recent works under a programme of HLF improvements (1.3 above) have seen the rebuilding of the Pearl Engine house chimney by AIHT, which was a significant landmark until its collapse in 1986. It once again forms one of the key skyline features of the mountain along with the adjacent engine house (re-roofed as part of the same programme of works), and the windmill (conserved in the same programme of works). Also to be mentioned as a key visual feature is the head frame above the Morris shaft established by AMplc in the late 1980's. This is in a prominent position on the north-west side of the mountain, and is particularly visible from the B5111 Llanerchymedd to Amlwch road which runs over the north side of the mountain. The surrounding landscape is still largely agricultural; the only settlements clearly visible being those of Amlwch to

Parys Mountain from the north-east, with the Morris headframe, windmill and re-erected Pearl Engine House chimney all visible from left to right

Parys Mountain from the south-west, with the Morris headframe and windmill visible. Wind turbines are visible to the right of the picture.

View south-east from the footpath that crosses between the Hillside and Great Opencast mines. Wind turbines are clearly visible, though not dominant, in part because the viewer is looking down on them, and because they only occupy a part of the view. The small settlement of Penygraigwen lies just beyond the turbines.

J 'Warwick' Smith 1790 'One of the Copper Mines belonging to the Paris Mountain Company' (National Library of Wales)

the north and Pensarn to the east. On the south side of the mountain is a windfarm of over 20 turbines. These tend not to intrude upon the view from outside, partly because they do not lie between principal roads and the mountain and partly because they are lower in height. They do, however, lie between the small settlement of Penygraigwen (known to have been occupied by miners) and the mountain. Though once again the scale is such that the landscape is able to largely absorb the impact, they do lie on the route taken by miners when walking from the settlement to the mountain. When viewed from the mountain, the turbines are more clearly visible within the landscape, but because they lie partly below the viewer, the scale of the impact is lessened.

Full visual appreciation of the upstanding archaeological remains is not readily available from outside the mountain. Though the windmill, Pearl engine house and chimney, and Morris shaft head frame are significant visual features, along with the multi-coloured industrial waste tips, full appreciation only comes from walking over the mountain. This reveals the full range of colours of the tips, the great opencast and lesser opencast, and the precipitation pits. Other lesser structures need a keen eye and some knowledge to appreciate, though a trail around the mountain designed by Amlwch Industrial Heritage Trust is of considerable help in this respect (1.3 above).

The 18th and 19th century artists, seeking the sublime, made no effort to record the mountain from outside, but concentrated their efforts on the full spectacle of the mining and quarrying being undertaken on the mountain. These pictures, and the views contained within them, are an important record both of the mountain and of the early years of the Industrial Revolution, recording the largest copper mine in the world. Many of the paintings are by John 'Warwick' Smith, who visited the mines on several occasions, and was also accompanied on at least one occasion by the artist Julius Caesar Ibbotson, who painted a number of scenes. The Parys mine paintings by Smith are considered by Peter Lord to be some of his finest (Lord 1998, 24), and he suggests the imagery is that of human endeavour equalling the hand of God in the creation of vast sublime landscapes (Lord 1988, 25). This was taken a stage further by the artist William Havell, whose large oil painting of 1803-4 hangs at Plas Newydd, home of the Marquess of Anglesey, and part owner of the mines.

Full appreciation of the landscape is really only possible from on the mountain itself. This view looks south-east towards Mynydd Bodafon. The Mona mine yard buildings are visible in the centre before the land drops away. The turbines are slightly higher from here, which increases their dominance.

3.3 The prehistoric landscape

There is very little evidence for the nature of the prehistoric landscape. Though much of the area is likely to have been more wooded, there are no pollen studies from this area of Anglesey to confirm this. There are also few prehistoric sites or finds known from the immediate vicinity of the mountain. The closest is a Bronze Age barrow (possibly two barrows) at Pen y Fynwent (PRN 2100, 2101; SAM An 125). Adjacent to the barrow is a pentagonal earthwork of probable late prehistoric date (PRN 2102; SAM An 124). The barrow lies at a height of 88m OD, approximately 1.5Km to the south-west of the mines. The mountain is clearly visible from the barrow. The known Bronze Age workings are underground, and cannot be appreciated from the surface.

Looking north with the Bronze Age barrow in the foreground, and the mountain in the background. Wind turbines are located just to the east, but do not impinge on the direct line of site between the barrow and the mines.

4. HISTORICAL SUMMARY

The historical and archaeological sections below are essentially those written by David Gwyn for GAT Report 292 (1998), but updated to include new information and new references. Sites are identified by their Primary Reference Number of the Historic Environment Record.

4.1 Bronze Age Period

Prehistoric mining on Mynydd Parys was first postulated in 1796, when Christopher Sykes referred to cobblestones and fire-set drift workings, which had already been quarried away by the open-cast workings, but which were still a recent memory. He considered that these workings were pre-Roman (Briggs 1976, 43).

In 1937 Oliver Davies investigated, with a series of trenches, an ancient tip near the Oxen Quarry on the north side of the mountain near the windmill. Within the tip he found twenty-four stone hammers and some charcoal and other artefacts, which he assigned to the "Old Celtic" or Roman Period (Davies 1937, 229-41).

A subsequent investigation by the Early Mines Research Group in August 1988 located Oliver Davies' original trenches. The Group carried out further trenching and soon found stone hammers and associated flakes. A layer of charcoal gave dates within the range 2000 - 1500 B.C., the Early Bronze Age, some of the earliest dates for Bronze Age mining recorded in Britain (Timberlake 1990, 15-21).

Other stone hammers have been found during mining operations in the last century (Stanley 1850), and survival of prehistoric remains underground has been confirmed following exploration carried out after 1995, when entry was gained into the underground workings (Jenkins 1995).

Hammerstones have been found in several workings, and radiocarbon dates from charcoal samples have dated activity to the early centuries of the second millennium (see Archaeological Summary below for a description of these findings). The full extent of the prehistoric underground workings are unknown, but there is considerable potential for the discovery of further deposits.

4.2 Roman period

The tradition that there has been Roman mining on the mountain is itself an old one; it is first recorded on a map of 1764 (HRO D/KK/534), which shows "Roman workings", and clearly the belief was impressed on the mines' many visitors. Thomas Pennant was apparently the first to connect this tradition to the discovery of copper cakes at Llanfaethlu and at Caerhun in Dyffryn Conwy (Pennant 1781, 275). Since then a total of twenty-seven copper ingots which can be ascribed to the Roman period has been discovered in Wales, eighteen on Anglesey (two on Mynydd Parys itself), six in the former county of Caernarfonshire and three in Clwyd. None has been discovered in England, and one in Scotland may be a reworking of scrap metal (Tyler 1982, 352-9). Others have been discovered in Brittany and South of France (Tylecote 1990, 69-70). They are plano-convex, about 1' in diameter and about 21/2" deep. Analysis has revealed they contain about 98% to 99% copper. The circumstantial evidence for Roman copper working at Mynydd Parys is therefore extremely strong.

4.3 Medieval and Early Modern

No Medieval mining is recorded at Parys Mountain. It was however during this period that the mountain gained its present name, from Robert Parys the Younger who in 1406 was commissioned by Henry IV to collect fines from the Anglesey supporters of Owain Glyn Dwr. He was given the mountain and surrounding lands as a reward for his services (Rowlands 1981, 15-16).

The first indication of mining after the Bronze Age is a map of Traeth Dulas and Amlwch port, annotated in secretary hand, and otherwise also typical of Tudor cartography, which records that the mines lay one mile distant, possibly at Henwaith ("old workings"), exactly a mile from the port, where later documents also suggest early mining may have taken place (Public Record Office SP 46/36 MPF 11, also discussed in Hope 1994, 16-17, and accessed by PUG). Sir John Wynn on several occasions expressed an interest in the Anglesey copper mines. His letters indicate that mining was taking place on Anglesey in the 1570s for in 1607 he refers to "a great mineral work in Anglesey 28 years ago that one Mr Medley had undertaken by boiling a quantity of iron in water. It made Alum and Copperas and transmuted iron into copper" (NLW Wynn Papers 470). Absalom Francis, the mining engineer, who prepared a report on the Mona Mine in 1880, remarked that in an area "300 fms. to the east of the present workings" shafts and workings dating from the seventeenth century, though reworked forty years previously, were still to be seen - and that further to the east again, and reaching almost to the road, there were traces of ancient mining reaching almost as far "the road, which forms the eastern boundary" (Mining Journal 1880, p. 134). Six hundred yards east of Carreg y Doll lies the dwelling

Henwaith where a map of 1764 shows both current and past operations (HRO D/KK/534). When the modern phase of operations began in the 1760s, there are references to opening out old works (BU Mona Mine 242), but no dates are mentioned. However, in 1698 there is a reference to "the prince's mines at Trysglwyn" (Dodd 1926, 92), suggesting that some working was going on in this period.

4.4 Modern period 1761-1851

In 1763 Messrs Roe and Co. of Macclesfield were negotiating for a lease of the eastern half of the mountain, the farm of Cerrig y Bleiddiau, the site of the future Mona mine, with Nicholas Bayly, the sole landowner, where work had been going on since about 1761. In September and October 1762 Sir Nicholas made significant discoveries, and a payment is recorded to a Mr Cartwright, the agent, in 1764. Roe and Co. were granted a lease in 1765 and according to legend the discovery which confirmed the mines' future was made on 2 March 1768 by an experienced Derbyshire miner called Jonathan Roose in a shaft sunk at Golden Venture (Rowlands 1981; Harris 1964, 18-35; Smith 2005).

In 1770 Bayly had begun mining on Parys Farm, the western half of the mountain, but ran into lawsuits brought by joint owner, the Rev. Edward Hughes of Llysdulas. These were to grumble on for several years, in the course of which Hughes secured the services of the attorney Thomas Williams. By 1774 Hughes and Williams were in partnership to work the western mountain, which came to be known as Parys mine, and with Williams' outstanding commercial skills, soon established offshoots in the form of smelters at Ravenhead in Lancashire and in Swansea, warehouses at London, Birmingham and Liverpool, and works at Holywell in Flintshire, Penclawdd in Glamorgan and Temple Mills in Berkshire (Rowlands 1981, 22-36; Harris 1964, 36-54). For this he came to be known as "the Copper King", though to his workmen on Mynydd Parys he was always Twm chwarae teg ("Tom fair play").

This rediscovery of the mine in the late eighteenth century led to Mynydd Parys rapidly becoming the most productive copper mine in the world, resulting in a short-lived boom which was to affect not only the previously rural solitudes of north-east Anglesey but also the copper trade throughout Britain, and beyond, for it was in this period that the industry began to operate on a global scale.

The scale of output from Mynydd Parys represented a serious threat to the established Cornish copper industry, forcing them to mine deeper and obliging them to invest in ever-more sophisticated pumping machinery (Pascoe nd, 36); it enabled Thomas Williams to break the hold of the Swansea smelters on the copper trade, and ultimately to control half of the British industry (Toomey 1985, 7). Between 1773 and 1785 output exceeded 3,000 tons per annum.

Messrs Roe and Company departed the Mona mine in 1785, and Bayly's son, Henry Paget, Earl of Uxbridge, decided to work the mine directly, with Thomas Williams as agent, his Lordship having concluded that Williams' entrepreneurial skills more than outweighed the fact that he had represented the Llysdulas interest against his father only eleven years before.

By the early nineteenth century the mines were in decline, but were reorganised in 1811, when Vivian and Sons of the Swansea copper smelting firm became directly involved. Following the death of Thomas Williams in 1802 the Mona mine had come to be owned by Lord Uxbridge and the two surviving Williams brothers; they, in conjunction with the Rev. Edward Hughes, held the Parys mine also. In 1811 the Williams brothers sold their shares to Uxbridge, who set up a company with R.H. Vivian and J.H. Vivian as his partners. The reason for the Vivians' involvement is still a matter for debate; it may have been an attempt to break into the Liverpool market, and it may have been connected to the fact that they were able for a number of years to supply the mines with coal - though the number of furnaces at Porth Amlwch was reduced between 1811 and 1817, and the Vivians withdrew in 1826 (Toomey 1985, 81-9). However, the Mona mines acquired a valuable asset in this period in the person of their new manager, the Cornishman Captain James Treweek (Rowlands 1963, 1-15). Thereafter, in John Rowlands' phrase, the mines which had wrought havoc with the Cornish copper industry only a few years before, became "administratively a Cornish colony". Despite all the charges of nepotism that were levelled at him, his managerial and technical expertise, combined with the Vivians' capital, enabled him to restore the mines to some prosperity throughout a period when smelters were increasingly being supplied from Chile and Cuba, later from Michigan, Spain and Australia (Toomey 1985, 52-81). The Amlwch smelters in this period not only served Mynydd Parys but also ores from Cwm Dyli, Drws y Coed, Llandudno, Sygun and Simdde Dylluan (BU Mona Mine 3613). Some of these were brought in as fluxes for the smelting process.

By 1833 Treweek controlled most operations, including the precipitation pits jointly operated by the Parys and Mona Companies. His death in 1851 was the end of an era for the mountain.

4.5 1851-1939

Operations from the mid-nineteenth century onwards were on a small scale only. The East Parys Mining Company Ltd was registered on 14 April 1858 but only operated for a couple of years. Hardly more successful was the Parys Mines Company Ltd, registered in 1860, in which the mining consultants, John Taylor and Sons were major shareholders, but their operations seem not to have outlasted the decade.

Parys Mountain Mines Ltd was established in 1870, and seven years later a special resolution was passed by the shareholders to sell the Morfa Du portion of the Company's property to the Morfa Du Mining Company. This latter Company was formed by Robert Oldrey, a principal shareholder in the Parys Company, to work the Morfa Du Mine.

On 24 March 1879 the Parys Copper Corporation Ltd was formed to acquire the business of Parys Mountain Mines Company Ltd. Again Oldrey was a shareholder, but the names of the Watson Brothers, Henry Dean, Charles Parry, all sharedealers, also appear on the list. Company records confirm that various agreements were made concerning discounted prices of share. J. Watson, for example, was one of twenty people in 1879 to receive shares discounted by 50%, instead of the going rate of £1. Much of the work in this later period of mining took place on the Carreg y Doll Lode 90 fathom level. The Company was wound up in 1885 when a special resolution was passed to merge the Parys Mine with Mona and Morfa Du Mines. The new company was to be called Mona and Parys United Mines Ltd. No records are believed to have survived of this new company, which is unlikely to have been floated on the stock exchange.

Elsewhere on and around Parys Mountain, other mines came into being. The East Mona Company was formed in 1860 to work copper at Tyddynmawr, to the south-east of Amlwch. This organisation was to be managed by Captain Tiddy, but seems never to have done any work. The South Parys Copper Mining Company and the North Parys Mining Company were registered in 1863 and 1864 respectively, but neither company appears to have been successful.

The Mona mine was leased on 20 April 1866 for a period of 31 years to Thomas Fanning Evans and John Wynne Paynter. The smelters at Amlwch were still in production, as a document of 1880 indicates that part was in lease to Henry Hills, who was also smelting Parys ores. Bryan Hope also gives an account of the ore being used for the production of sulphuric acid by the same man (Hope 1994, 90-91). There are also references in the Mining Journal for 1871 to the Mona Mines and Smelting Co. During this period, it seems that the Mona Mine operated as a private company, but in 1880 Mona Mines Ltd appears as a registered company, and once again Robert Oldrey is the principal shareholder. Capital was to be limited to 8,000 shares at £5 each; Oldrey held 1,685. Thomas Fanning Evans, John Wynne Paynter and Hugh Roberts were also principal shareholders, as they were paid for the lease of Mona Mine in shares for the new company. The Company files give a clear indication of what was owned by the previous unregistered Mona Company, and these include land and a pool (369 acres), Trysglwyn Farm (100 acres), a paint mill at Amlwch, a smelting works at Amlwch Port, quays at Amlwch with bins and warehouses, rights under the Amlwch Harbour Act and plant and machinery on the premises.

Early reports by W. Hughes indicates that this company set to work with a will; a new engine was purchased, and smelting operations continued. Underground operations extended to the south and east and Lemin Shaft was sunk. However in 1885 the Company was wound up.

The Mona and Parys mines were eventually merged when Mona and Parys Mines Ltd was formed in 1899. Thomas Fanning Evans had died by this time, but the lease for the mines was still held by his family who sold it to the company for £22,000 in cash and £23,000 in shares. In the early years of this Company some underground work was carried out, but it seems likely that much of their output was derived from the precipitation of copper and ochre. The centre of operations was probably the ochre works adjacent to the Joint Level adit, as a photograph dated on internal evidence to about the turn of the century shows work going on here (LIRO WSB/30).

By 1921 a Receiver had been called in but precipitation continued. In 1928 Thomas Fanning Evans II informed Companies House that the Mona and Parys Mines were "now a private concern carried out by myself" and they continued on this basis until 1958, when the last of the precipitation pits were abandoned (BU Fanning Evans Mss).

4.6 Post-World War II

Since the mid-1950's a succession of companies has carried out geological exploration on Parys Mountain.

Between 1955 and 1957, Anglesey Mining Ex-

ploration Ltd, a subsidiary of New Consolidated Goldfields, carried out a detailed surface and underground geological survey on the Mona and Morfa Ddu Mines. From 1961 to 1962 exploration was continued by Anglesey Copper Mines (UK) Ltd., a subsidiary of the Irish-Canadian Northgate Exploration Ltd, who carried out further geological mapping and drilled eleven surface boreholes. Canadian Industrial Gas and Oil Ltd (CIGOL) explored the site from 1966 to 1970 with several partners, but despite drilling fifty-two boreholes, no promising reserves were found.

On 16 September 1971, the mineral lease for an area of about five square kilometres was granted to Parys Mountain Mines (UK) Ltd. for a term of ninety-nine years from 25 March 1969. A further eighteen boreholes were drilled between 1971 and 1972 by the Intermine Ltd/Noranda Ltd partnership.

Cominco Ltd, who began work in 1973, was more successful. Having initially concentrated exploration on the traditional bluestone areas, they turned their attention northward and by 1978 had made significant discoveries of bluestone.

Anglesey Mining plc was formed in 1984 as a subsidiary of the Imperial Metals Corporation of Vancouver , whose Chairman, Dr Hugh Morris had previously worked for Cominco; the company obtained rights to explore under the 1971 lease from Intermine Limited. Anglesey Mining plc was floated on the stock exchange in May 1988 raising £5.5 million which was used to sink the 300m deep Morris shaft from which to explore and later extract the mineral resources which had been discovered to date; two lateral tunnels were driven at the 280m level to test these resources. About 2,000 tons of ore were mined and 800 tonnes were subjected to milling trials.

Unfortunately low metal prices on the international markets in 1991-2 led to the suspension of operations. Further exploratory drilling campaigns from the surface took place in 1997-8, 2004-5 and 2007-8. Hopes were also raised by the involvement of potential joint venture partners from Australia in 2007 and 2008, however there have been no significant site operations between then and 2014.

5. ARCHAEOLOGICAL SUMMARY

(Numbers in brackets refer to the Primary Reference Number (PRN) of the regional Historic Environment Record (HER) held by Gwynedd Archaeological Trust (GAT)).

5.1 Extraction Sites

5.1.1 Pre-Modern

Evidence of pre-Modern extraction has been discovered at several points. The hammer-stones discovered by Oliver Davies in 1937 lay immediately to the north of the Oxen Quarry, an open working to the north of the main Modern opencasts, and it is possible, as Simon Timberlake suggests, that this was itself a copper-extraction area (3,551). There is no evidence of shot-holes in its shallow face, though any copper has long been worked out here, and the quarry possibly used for stone subsequently (Davies 1939; Timberlake 1988).

Other hammer-stones have being found during mining operations in the last century (Stanley 1873, 59-62), and some 142 have been found in recent decades (*pers comm* David Jenkins). It is possible that other surface sites may also preserve evidence of Bronze-Age extraction, such as the quarry to the south of the mine (35,533).

More recently, evidence for pre-Modern underground working has been discovered. Access was regained by PUG into the Parys incline shaft in 1995 (35,202; 35,210), an entry not marked on the abandonment plans of 1876, which, following the de-watering in 2003, leads to levels at 10fm, 16fm, 20fm, 30fm and 45fm depths (Dyffryn Adda water table). Some lengths contain compressed air piping, which suggests that these were the focus of the abortive re-opening of Parys in the late 1870s and early 1880s. Two areas of prehistoric working have been identified, one containing four sites lies on the North Discovery lode, and a further site on the Carreg y Doll lode. At the latter the roof of 18thC workings broke into the bottom of a sloping open passage extending up dip some 15m before becoming choked with surface spoil. Draughting observed under strong surface wind conditions suggests it must be close to the surface which survey locates in a quarry in thick (>20m) deposits of 18thC spoil . The passage is ca.1.5m in diameter and, although most sections of the walls and roof are determined by planar jointing or cleavage, some parts display the rough concave surfaces that are considered diagnostic of fire-setting. The bottom of the passage contains a 0.5m section through well-banded deposits including a 10cm thick branch which has been dated to the Early Bronze Age (c. 2000 BC). A series of radiocarbon dates from the North Discovery lode sites indicates mining was active within the period 2000 – 1700 BC. Some 136 mauls or hammerstones have been collected from the mines, 42 from surface sites and 94 from underground workings (Jenkins forthcoming).

There are hints in the documentary evidence of other methods of extraction before the Modern period. Thomas Fanning Evans observed in 1878 that copper-rich peat on the southern perimeter of the mines had been burnt and smelted at times in the recent past (Hope 1994, 86) as at Dolfrwynog near Dolgellau, and in 1826 Victor-Frère-Jean observed that copper found in the turbary had been smelted there, by, he suggested, the Romans (Victor-Frere-Jean 1826, 229-38). A map of 1764 shows a turbary as occupying the site of the later Dyffryn Coch precipitation systems, overlooked by a “mineral well” and “the old washing place” on a site to the east of the present Mona mine yard. These may have been the source of a stream which impregnated the turf downslope, and also have been the focus for Sir John Wynn’s experiments in 1607 (NLW Calendar of Wyn Papers, 455, 456, 460, 462).

Bronze Age workings (Copyright D Jeenkins).

5.1.2 Modern

Within the Modern period, the Mynydd Parys mines were worked by three different methods - in two large opencasts, known as the Great Opencast and the Hillside Opencast, as an underground mine accessed by shafts and footways, and by precipitation of the waters from the mine at a number of locations.

Opencast working

The two large opencasts (Scheduled Ancient Monuments) are the most visually spectacular features of the whole site. Though it is only 30m deep, and the Hillside is 50m deep, the steep sides and the vivid colours give them both an impression of considerable depth. Though the fearsome overhang on the north side of the Great Opencast which was commemorated in a number of early paintings has now been obliterated by gradual collapse of the rock face, both recall the working methods of the eighteenth century.

An account of the first phase of modern operations at the two mines, written in the early nineteenth century, speaks of extraction as being carried out initially by both underground and open workings. “The method in the Old Mine (Mona) being to dig pits or shafts wch are said to be 30 yards deep before they come to the bed or rock of ore .... In the new work (Parys) they also use this method but by far the greatest part of their Ore, being nearer the Surface is raised by taking it away, at least a great part of it, by wch they have made a tremendous Chasm”(BU Mona Mine 3544, 9).

There are several references to both the opencasts as having come about as a consequence of underground workings being deliberately collapsed (Hope 1994, 33). An engraving purporting to show the Mona mine in 1780 shows an open quarry in the face of which seven levels, each large enough to take a horse and cart, have been driven (Mining Journal 12 June 1880, 670), and a map of the Mona mine prepared in 1786-8 marks a series of falls in the Mona mine’s share of the Great Opencast (NMR C8235).

The Great Opencast from the west looking towards the summit windmill

The Hillside Opencast may have come into being in part by this method. It is possible that the large opening or “heavy hanging” on its west side known as Gwaith Robin Ellis is a survivor of this eighteenth-century tunnelling technique. The same map of 1786-8 shows the site of the future Hillside Opencast as partly a fall and partly as an area of

underground workings accessed by shafts. No less than 144 are marked, of which some were already out of use and had been capped (NMR C8235).

The Great Opencast was already of enormous size by the time of the first visual records of the mine, in the 1780s and 1790s, which show deep pits, from which the ore was wound by windlass and horse-gin. Opencast exploitation of copper ore is a feature of a number of other substantial copper workings elsewhere in the world, such as Stora Koparberg in Sweden, and is a particularly apt method where, as at Mynydd Parys, a particularly wide bed of low grade ore lies at a very slight distance below the surface.

Though it is likely that the opencasts have quarried away very many earlier features, including the alleged Roman workings, traces of other surface workings were observed. To the north of the Hillside Opencast are three parallel cuts, each about 10m deep, orientated south-west to north-east, which appear to contain no evidence for blasting in the form of shot-holes, and no evidence of mineralisation, but which have yielded neither charcoal for fire-setting nor hammer-stones. These workings may be typical of early Modern practice on the mountain, and perhaps date to the mid-eighteenth century.

Underground working

As well as the open workings, over 100 mine-shafts giving access to some 10Km of underground passages accessing large underground workings (stopes) are a common feature on Mynydd Parys. The shafts have for the most part been capped with a concrete block, and identified by a unique number cemented into a concrete pillar set into the ground near each shaft-site. Others have been blocked by fallen rubble to within a number of metres of the surface, though those in spoil have collapsed badly, creating an ever-larger crater as the sides continue to degrade. Where it is possible to form an estimate of their size, most appear small in cross-section (e.g. 2m x 3m or less), some with ginging visible, others cut straight through bedrock, of a size typical of late-eighteenth and early nineteenth-century workings, making use for the most part of horse-gins and hand-windlasses rather than mechanical prime-movers (see below). Three level adits were also observed.

It is known from the documentary record that the near-exhaustion of the ores accessible by opencasting and shafts up to 45fm deep in the early nineteenth century obliged the managers to revive and extend the practice of underground working, particularly in the area to the north and east of the opencasts. It is likely that most of the surviving shafts date from this period, and in some cases documentary evidence survives for their sinking. Early maps, however, show existing shafts which had already been capped (NMR C8235), and it is possible that shallow shafts from the earliest Modern phase of workings may come to light in the event of ground-disturbance or collapse of wooden capping.

Greenly (1919) identified 12 mineral lodes, many of which, such as the Carreg y Doll lode, were worked principally from shafts. The deepest shaft was Gwens Shaft which went down 150fm (174m below sea level). The Cairns Shaft, on the summit, lay at 146m above sea level, giving a total working depth of 320m. The shafts are linked by 20Km of underground passages, ca. 10Km above the water table (determined by the Dyffryn Adda drainage level at 45fm), pumping being required for those below, the output of which was fed into the precipitation ponds. Approximately 100 shafts were capped in 1980, though a few others not capped are known to exist.

Precipitation

Ample archaeological evidence survives of the third method of extraction, precipitation of copper by iron in water, in the form of extensive chequer-board patterns of shallow ponds, some covering many acres, often in conjunction with larger and deeper lakes for the extraction of ochre.
Precipitation was a low-cost method which sought to extract the copper ore from waters flowing out of the deep mine or which had been passed through the tips, either as rainwater or deliberately by sparging. Several different accounts have been published of this method, of which the following is perhaps one of the clearest and most detailed:

“The water is raised by means of wooden pumps, and stored in reservoirs specially prepared for its reception. Here it deposits any clay and grit contained, and when clear it is tapped off as required into their precipitation tanks. These tanks are filled with old iron, and the cupreous water is allowed to flow first into the head “pit,” and from it continuously flows through a series which is lengthened or shortened as found necessary with the varying strengths of the water passing through. Four times a year the precipitate thus obtained is thus collected. The water is first drawn off, all the iron is then placed upon the “backs” of the wavy bottom, and the copper attached to it is washed away by throwing violently against it by means of scoops the water still remaining in the hollows. This process accomplished, the precipitate is allowed to subside, and the clear water is drawn off by taking out the plugs placed in the middle of each trough. The precipitate is then

carried in casks to a pit, where it gradually acquires the consistency of soft mud, and is then taken to a reverberatory furnace where it is dried and made ready for smelting. The water afterwards flows into large reservoirs, some of several acres extent, and there by a natural process deposits a sediment of sub-persulphate of iron, or precipitated yellow ochre. Some thousands of tons of this article are annually sold; it is used largely as a gas-purifying material, and considerable quantities are calcined for the production of the various iron oxide paints and Venetian red. These mineral waters must have issued from the ground for a very long period, for south of the mountain there is an extensive peaty tract, portions of which are cupreous, while others contain so much ochre as to produce an excellent gas purifying material. When the price of copper was so high the cupreous peat was largely burned, and the ashes thus obtained, containing from 2 to 4 per cent of metallic copper, were smelted with others ores of the mine. The streams of water proceeding from the mine are of a deep port wine colour when first pumped out, they gradually become lighter in colour as they deposit the ochre; when they enter the sea they impart to it a yellow tinge, which sometimes stretches out a mile or more into the channel" (Mining Journal 1878, 943).

Whilst there are a great number of separate systems, many appear to run into each other, such as those grouped around the Great Opencast, which all make their way by one means or another (for example the Dyffryn Goch adit driven south from the opencast) to the Dyffryn Coch systems, which formed the subject of a GAT measured survey in 1995 (Unpublished GAT 1995). The Henwaith pits were recorded prior to works to reduce contamination (Unpublished GAT 2011), and the extensive Hillside precipitation system has also been surveyed (Unpublished GAT 2010).

Precipitation of copper from water was practised at a number of mine sites throughout Europe, though none on such an enormous scale as Mynydd Parys. It is not entirely clear how knowledge of the possibilities of copper precipitation might have spread, or whether separate discoveries took place. However, from the 16th century onwards, the most advanced and the most influential mining-fields in terms of technology-transfer were those of the German-speaking world, which in practice also meant Hungary and Russia, whither many German miners went. A few made their way westwards - the Hochstetters to the Mines Royal in the 1560s, German labourers to Talybont in Cardiganshire in the 1660s – and they were enough to bring the use of railways, flat rods and explosives with them to the British isles. However, there is no evidence that they

Survey of Henwaith pits (GAT 2011)

brought with them knowledge of precipitation, and the practice is mentioned in neither Biringuccio's Pirotechnia (1560) nor Agricola's De Re Metallica (1556).

As well as the movement of personnel, written sources can also be instrumental in technology-transfer. For many years a state of warfare or at best armed truce between Christendom and Islam into the 18th century made it difficult to learn much about what was happening in those mines which lay near the border between the Hapsburgs and the Ottomans. Even so, there is evidence for the visits made to mining areas by interested observers from elsewhere in Europe, who often wrote up an account of their travels. The digitisation of this historic source-material online has made it possible to trace both the evolution of precipitation as a technology and dissemination of knowledge.

Thomas Pennant's account of precipitation at Parys, published not long after the mine had broken through to the low-grade but easily accessible copper ore in 1768, mentions that precipitation was:

... far from new; it has been practised long in the Wicklow mines in Ireland, and above a century in those of Hern-grundt in Hungary, where it is called Ziment Copper*.

The mine at Herren grund (Hungarian: Úrvölgy) and the principal nearby mining town of Neusohl (Hungarian: Besztercebánya) now go under their Slovak names, Banská Bystrica and Spania-Dolina respectively.

Pennant continues:

The waters of the Hungarian mines are much more strongly impregnated with copper than those of Parys mountain. The first effects its operations in about twelve or twenty days; the last requires two months.'

He footnotes two sources, one of which is 'Brown's travels', the other of which is 'Keysler's travels'. The first of these was from the pen of Dr Edward Brown, son of Sir Thomas Browne of Urn Burial fame, who embarked on a journey through central Europe in 1668 which took in the mines of Hungary.

There are also two Springs of a Vitriolat water which turn Iron into Copper, called the old and the new Ziment; these springs lye very deep in the Mine, and the Iron is ordinarily left in the water fourteen days. These waters are very profitable, seeing that the worst sort of Iron, and useless old Iron is hereby turned into the purest sort of Copper, which hath this commendation above other Copper to be more ductile, malleable, and easily melted; and I have melted it without the addition of any other substance, without difficulty... Some will not have this to be a Transmutation of one Metal into another, but that this Water of the Ziment being saturated with a Vitroleum Veneris, and meeting with such a body so ready to receive it as Mars, it deposeth Venus, who immediately insinuateth herself so far into Mars, that she doeth dividere & imperare, and at last she substitutes her own body, and precipitates that of Mars.

The second source is John George Keysler, Travels Through Germany: Hungary, Bohemia, Switzerland, Italy, and Lorrain, which does not appear to have been digitised but which is a translation of Johann Georg Keysler, Neueste Reisen durch Deutschland, Böhmen, Ungarn, die Schweiz, Italien und Lothringen (Hannover 1751). The relevant passage reads in modern translation:

Herrengrund, a mile from Neusohl, is also famous on account of the spring which under usual conditions [will have to check this] changes iron into copper.

In these circumstances, the water, wherein the iron is placed, is nothing more than a solution of copper in which the iron is dissolved, leaving copper particles.

This occurs over two or three weeks; if the iron remains too long in the ore-rich water (camentwasser) it disintegrates into a copper powder. One can also carry out the same experiment with ordinary water in which a strong solution of Hungarian or Cypriot vitriol has been dissolved. (Other types of vitriol are not suitable because they draw out the iron).

Where the water flows away from the above-mentioned Herrengrund spring, a lot of Berggrun (?verdigris), Borax or Chrysocolla, nothing more than a coating/layer of uberreife (?over-ripe/over saturated) copper, is washed out and is green in colour. Blue, green red and white vitriol are found in Herrengrund.

An earlier and more detailed account of the mine which Pennant does not seem to have seen is Luigi Ferdinando Marsigli's Danubius-Pannonico-Mysicus volume 3 of 1726. The text and the accompanying drawing make clear that copper-rich water flowing in three streams was collected in wooden tanks where the copper was precipitated. The drawing implies a fairly small system, and it seems to be intended as an accurate depiction of the mine rather than as reflection of the ideal qualities of such an undertaking.

The Reverend Dr William Henry of Dublin in 1751

described an apparently accidental discovery 'which happen'd not long ago', when a miner at Cronebane mine in County Wicklow left an iron shovel in the stream issuing from the mine, which became encrusted with copper. On this basis pits 10' by 4' in plan were built, with stone and lime sides and flag floors, perhaps from the local slate workings at ?, in which iron bars were laid. Yet both Brown and Marsigli are referenced by Dr Henry, which leaves open the possibility that both happenstance and published sources played a part in the general transfer of this technology.

Eight years later, an account was published by the naturalist Emanuel Mendes da Costa in The Critical Review under Tobias Smollett's editorship. Da Costa observes that water was precipitated from copper in mines in Cornwall, Yorkshire, Cumberland, and Derbyshire, and that 'some quantity of this ochre has lately been found in the copper-mines of Wicklow county in Ireland' (but does not mention Parys). He states that this method was to be found in Saxony, Bohemia, in Poland and in Sweden; but the greatest quantity, and of the finest sort, in the kingdom of Hungary. He translates directly from the mineralogist Franz Ernst Brückmann (1697-1753), who states that at:

Neusohl, in the mountainous territory called Herrengrund, in Hungary ... the waters of those mines abound with this substance; the miners, to collect it, turn and carry off these waters by numbers of wooden pipes, to great square wooden reservoirs, made of large planks, wherein the water deposits this green substance; when they have thus obtained a large quantity of the ochre, and that the reservoirs are incrusted with it to a good thickness, the water being turned off, they scrape off the chrysocolla, or green ochre from these vessels , then dry it and divide it into three sorts; the first sort, which is the worst or common kind, is that taken out of the first or upper reservoir, wherein the water first falls; the second or middle sort, is in like manner collected from the second reservoir; and the third sort, which is the finest and most valuable, they collect from the lower reservoir, or wherein the water flows out last of all: These reservoirs are placed above each other, but communicate by means of inclining wooden pipes, so that the first is placed higher than the second, and the second higher than third, and the water gradually flows from the uppermost to the lowest reservoir.

These ochres, thus collected, are afterwards exposed to a clear summer sunshine to dry, and are then put up for sale; the first, or worst sort, is impure, or gritty, and of a dusky green colour; the second sort is somewhat purer, of a middling colour, between the dark green of the first sort, and the bright green of the third or best sort; and the third sort is entirely fine, pure, and of a most beautiful bright green colour, and suffers no depurations or washings before it is used, as the other two sorts, which are again washed to free them from their heterogeneous parts.

At Richtergrund, about a mile from Neusohl, this ochre is also collected in the same manner; but not in so great quantities as at Neusohl.

The Encyclopaedia Britannica; Or, A Dictionary of Arts, Sciences, and Miscellaneous Literature Volume 2 (1797), the New Encyclopaedia (1807) and the Encyclopaedia Perthensis; or, Universal dictionary of Knowledge (1816) all quote and acknowledges Pennant word-for-word.

Kauffman in 1803 observes:
Copper dissolved by the vitriolic acid. At Herngrundt near Newsol in Upper Hungary, there are two springs, called the Old and New Ziment, so richly impregnated with Copper dissolved by the vitriolic acid, that iron thrown into them is dissolved by the latter, and the Copper precipitated in its metallic form, in the place of the iron. Some pits made purposely for this operation, are filled with the water of the springs, and old iron is thrown in, which in twelve to twenty days is taken out, and the Copper scraped off. The metal thus procured, differs little from native Copper. One hundred tons of iron by this method yield eighty-four to ninety tons of Copper. By the like process, such quantities of copper have of late years been obtained, from some spring issuing from the celebrated Copper mines at Arklow, in the county of Wicklow, // in Ireland, that these springs are now of as much consequence as the mines themselves. One ton of iron there, produces sixteen cwt of fine Copper, selling for ten pounds sterling a ton more, than the Copper fluxed from the ore.

Discussion

The evidence of Da Costa suggests that precipitation was introduced at Parys after 1759, and that it was already a well-known technology. It is unlikely that it was introduced directly to Parys by experts from central Europe, even though there was clearly interest in the practice. It is more likely that it had been introduced to the British Isles and Ireland earlier on.

The date for the introduction of precipitation to Mynydd Parys is uncertain, though it was certainly in use by 1771 (Smith 2005, 340; BU Kinmel 1807). Extensive pits on the south side of the mountain and in Dyffryn Coch, the valley to the south, are marked

on both mines on a map of 1784-6 (NMR C8235). By 1815 the joint level was in operation, which fed precipitation pits at Dyffryn Adda, to the north of the mountain, where a furnace to dry the precipitate had been constructed (NMR C8236). By 1824, if not before, the extensive systems on the east of the mountain, known as the Hillside precipitation pits were in existence (BL Maps 6135(1)).

5.2 Processing sites

5.2.1 Pre-Modern

Little archaeological evidence has been discovered to shed any light on pre-modern processing on the mountain. Simon Timberlake records the discovery of a stray find of copper slag at Mynydd Parys (PRN 35226), but considers that the hammer-stones were used for extraction rather than cobbing (Timberlake 1989, 20-21). The discovery of copper ingots at Mynydd Parys itself implies on-site smelting, and the extensive turbaries which are recorded on early maps would have provided fuel for the process. Ingots are recorded as having been variously stamped SOCIO ROMAE, NATSOL, IVFS and IVL.S (RCAHMW 1937, lxxxvii).

5.2.2 Modern

There are several detailed accounts of ore-processing at Mynydd Parys, which describe the various stages involved. Whilst archaeological evidence survives in situ for some parts of the process of treatment, others have left no visible mark.

Processing of the ore took various forms. The ore was hand-crushed and possibly jigged and buddled on site and some was calcined on site as well. Calcination, producing purple-red spoil, also took place at the smelter at Porth Amlwch. The preparation of the ore also yielded a number of useful by-products.

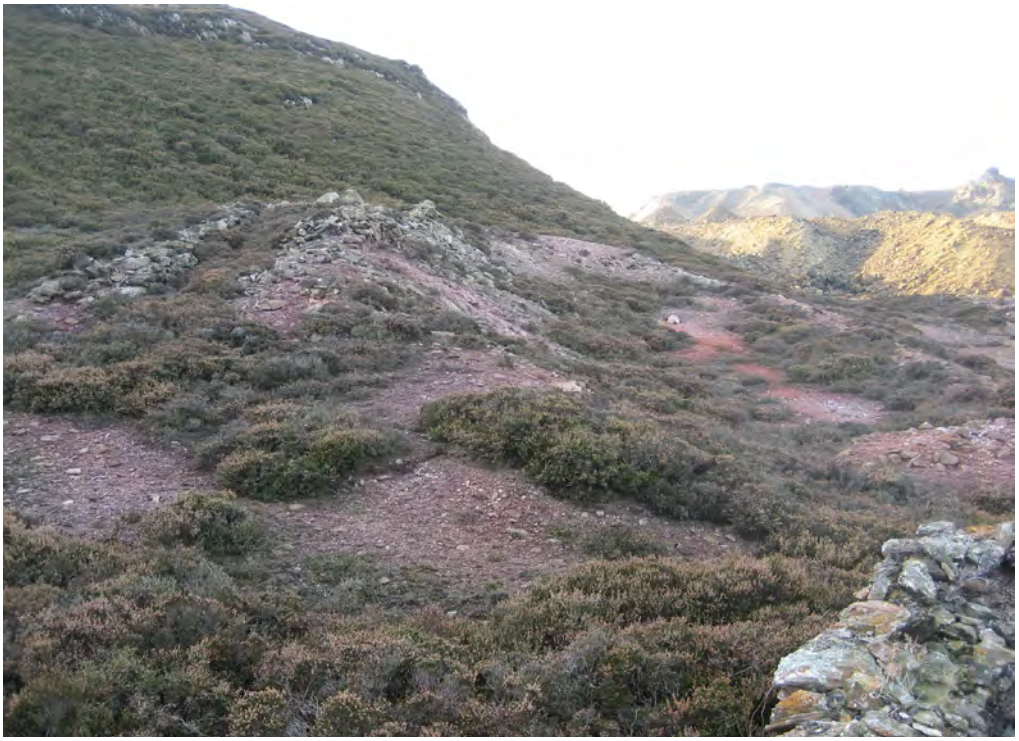
Mechanical processing

Faraday describes in 1819 how the ore, once raised from the mine "in large heavy masses .. is then thrown over a stage onto the ground below where it comes into charge of cobbers, principally women and boys. We came up to a large group of these, about 8 or 9 women were sitting on the ground in the midst of heaps of ore of the large and small, their mouths were covered with cloth to keep the dust of the ore from entering with the breath." The boys fetched lumps and the worthless rock was removed by cart (Tomos (ed) 1971, 79-80).

Evidence for this first stage of the process, in the form of cobbing floors, was observed at a number of points, most notably the badly-damaged but clearly extensive area known as Iard Charlotte (PRN 35280) in the Mona mine. This has been partly quarried away by twentieth-century reworking for roadstone of the spoil-heaps on which it was constructed. Here the coparledis ("copper-ladies") hammered at the ore, and operated jiggers. Until well into the nineteenth century this work was carried on in the open; a correspondent in the Mining Journal in 1871 suggested that it would be "a not unwise economy, as well as a philanthropic gesture, if the company were to provide for the showy and picturesque looking girls who work the jiggers a light zinc or galvanised iron roof over their heads" (Mining Journal 27 June 1871, 552). Owen Griffith's account, written in 1895-7, states that as many as eighty women might work together, housed in a long wooden shed (Griffith 1897, 41).

Archival evidence suggests these preliminary stages were increasingly being carried out by machines from the 1870s onwards. A crusher, powered by a steam engine, was at work in the Parys mine by 1872 (Mining Journal 17 February 1872, pp. 142-3), of which no archaeological evidence was observed, and a building known as the Calciner at Mona mine (PRN 35463) may have housed a rotary crusher or possibly stamps, but for which, conversely, no documentation has come to light.

Julius Ceaser Ibbetson c. 1790 showing women at work seiving the ore. (National Museum of Wales)



Mona Mine Calcining Kilns (SAM 136; PRN 35,495)

Calcining

The best of the ore produced by the first stage of processing was taken to the smelters at Porth Amlwch or elsewhere without further treatment, and the poorer rock or halvans was put through a number of other processes on site before it could be smelted. Buddling was practised in 1770, when payments are recorded to workmen building dams for buddles and to carpenters for building the buddles themselves, (BU Mona Mine 3750) and was revived from 1872 (Mining Journal 17 February 1872, pp. 142-3), but has left no visible archaeological trace. For most of the mines' modern history the poorer ore was calcined, initially near the sea-shore, but before long at the mines themselves (Rowlands 1981, 42).

Calcination is a process which removes sulphur from the ore by burning. In the early days of the mines, this meant burning the ore in oblong heaps between 4' and 5' high, which would be set on fire in the same manner as a brick kiln and left to burn for several months, a method little different from those set out in the pages of Agricola's De Re Metallica and the Pirotechnia of Biringuccio in the sixteenth century. In 1770 miners were paid for "cutting of Turff at the Turbary & cutting of Gorse upon the mountain for the burning of copper ore at the Undivided Estate at Paris Mt" (BU Plas Newydd 2242, 15-16) -- in other words, the Mona mine site. The residue would be broken with hammers almost to a powder, then washed. Turf was used in preference to coal in the early stages because substances carried by coastal vessel from one port to another paid a duty, at least until Thomas Williams finally succeeded in persuading Parliament to suspend it in 1786 (An Act for allowing a Drawback of the Duties upon Coals used in smelting Copper and Lead Ores, and in Fire Engines for draining water out of the Copper and Lead Mines, within the Isle of Anglesey, (26 George III cap. CIV)). The furnaces themselves would be rebuilt every few months (BU Mona Mine 3570).

Though initially the fumes of sulphur dioxide thus released were left to drift away, Roe and Company realised that sulphur (brimstone) could be manufactured from them (Hope 1994, 38); early accounts refer to a horizontal brick chimney over the roasting ore which would feed the sulphur fumes emitted from the ore into a brick arch 40 or 50 yards long and 6' high and wide. The sulphur would be condensed into a fine yellow powder 1' or more deep, then put into furnaces and gently heated into a liquid, drawn off through a cock, cooled to a solid and sold to the chemical industry and to gunpowder manufacturers (BU Mona Mine 3544, ff. 12r-14r).

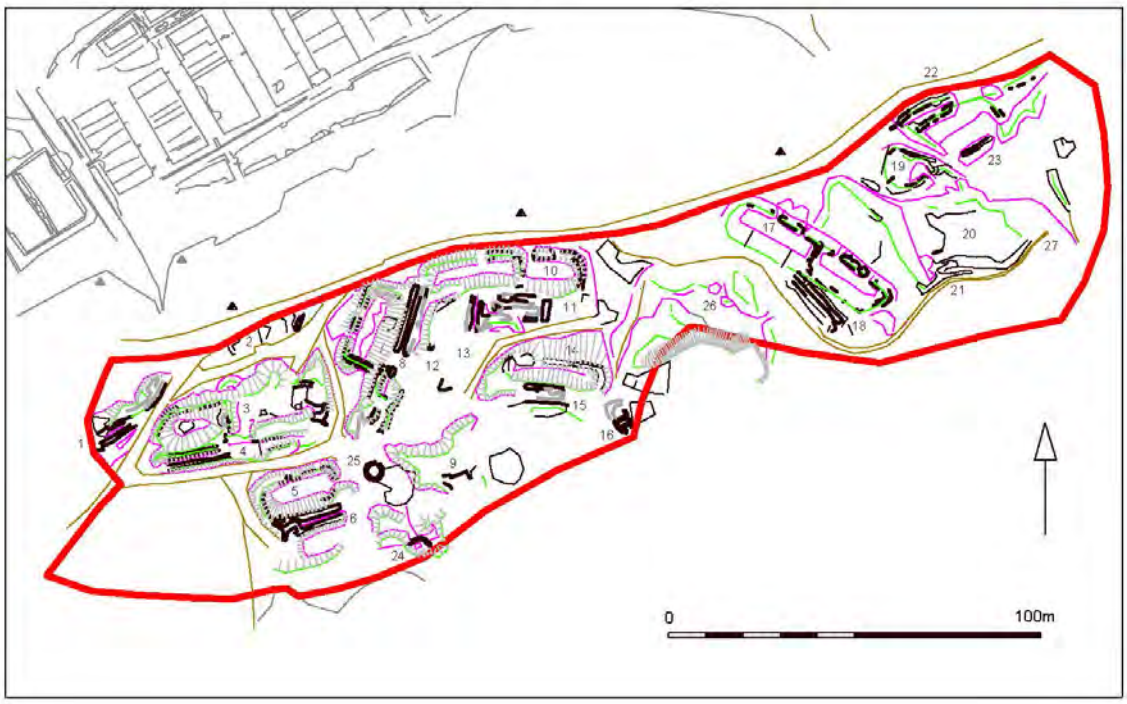
Slightly later eighteenth century accounts suggest that this process was before long being carried out on a more ambitious scale, involving heaps about 35' long, 10' wide and 10' high, held in place by larger pieces of ore, and into which four or five holes were made, in the manner of ash pits. Flues were constructed over the top of these heaps communicating with flues at ground level covered with earth. John Champion, who joined forces with Roe and Company to calcine Mona ore in exchange for the sulphur, used a batch process with large horizontal ovens similar to the original kilns (Hope 1994), and the Mona mine papers record the construction of

horizontal kilns, condensers and flues for calcining and sulphur extraction after the departure of Messrs Roe and Company in 1785 (BU Mona Mine, 3040). At least five are shown on the plan of 1784-6 (BU Bangor 31603), and Dr Lentin's letter of 1800 makes it clear that these were being used at the time of his visit (Rothwell 2007). Pennant gives a clear description of how the ore was burnt when he came to the mountain:

"For that purpose [burning] it is placed between two parallel walls of vast length: some kilns are twenty, others forty, and fifty yards in length; some ten, others twenty feet wide, and above four feet in height. The space between is not only filled, but the ore is piled many feet higher, in a convex form from end to end: the whole is then covered with flat stones, closely luted with clay; and above is placed a general integument of clay, and small rubbish of the work, in order to prevent any of the fumes from evaporating. Of late some kilns have been constructed with brick arches over the ore, which is found to be the best method of burning. Within these few years, attempts are made to preserve the sulphur from flying away; and that is done by flues, made of brick, whose tops are in form of a Gothic arch, many scores of feet in length: one end of these opens into the beds of copper which are to be burnt. Those beds are set on fire by a very small quantity of coal, for all the rest is affected by its own phlogiston. The volatile part is confined, and directed to the flues; in its course the sulphurous particles strike against their roofs, and fall to the bottom in the form of the finest brimstone; which is collected, and carried to adjacent houses, where it is melted into what is called in the shops stone brimstone." (Pennant 1783, 268).

A number of what appear to be later versions of these kilns survive, though the sulphur chambers are stone-built rather than brick. Six calcining kilns and their related flues and sulphur chambers were noted at Parys mines (Prn's 35204, 35206-9, 35211-13, 35215-17), believed to be for copper ore (GAT Report 788, 2009), and up to 15 at Mona (GAT Report 1198, 2014, Appendix 3), along with other structures on both mines that may also have been connected with calcining (35,463, 35,476), though the building known as the calciner is thought to have housed an engine and crusher (GAT Report 788, 20). The kilns themselves are visible as rounded oval depressions, anything up to 17m long and 6m across, some of which appear to feed into long but barely defined flues and which are associated with sulphur sublimation chambers, visible as parallel stone walls, typically 16m long, 1m high, each 0.8m wide and 0.6m apart. Around the kiln-sites the spoil is a distinctive pinkish colour.

However, it is clear that this was not the only type of kiln to have been used. Another method was adopted on the mine sites themselves and at the smelters at Porth Amlwch. Matthew Boulton in a letter to his son dated 1787 describes a visit to the "Anglesey Copper Mine" where he saw the kilns then in use for calcining the ore - conical brick-built structures from the top of which a flue led to a condensing chamber, where the sulphur was condensed in the form of "Flowers of Brimstone" in a separate chamber, "a large empty space built with brick in the Ground when that is nearly full it is put into a Cast Iron Cylindrical vessel & melted by a gentle heat



Plan of Mona Mine Calcining Kilns (GAT Report 1198, 2014)

into a solid form & ladled and poured into Moulds. This Brimstone is sold for the purpose of making Oyl of Vitriol." (Birmingham Reference Library Boulton and Watt coll., 6/6/85). The 1788 valuation speaks of "coal calciners and condensers" at Mona worth £1283 2/7d and "Horizontal do." worth £783 13/3d, as well as "cone calciners and condensers" worth £488 14 14/31/2d at the port (BU Mona Mines, 3040). Parys mine had allocated ground immediately to the north and south of the Great Opencast for new calcining kilns in 1815 (BU Bangor 31602) and these had been constructed by 1819, apparently of the horizontal variety (BL 6135(1)). A calciner, valued initially at £100, makes its appearance in 1832 (BU Plas Newydd, 167), and payments to calciners are recorded in the Mona mine wages list from when they begin in 1822 (BU Mona Mine, 105). A building at the Mona mine which has traditionally been known as the Calciner (35,463) bears no similarity to any of the other kilns and appears latterly at least to have housed an engine and rotary crusher. A lengthy leat (originally thought to have been a flue(35,476) runs through the building and towards the precipitation pits (GAT 2009, Report 788). On the northern part of the Parys mine are flues built into the sides of tips leading to the base of a chimney which may have been part of calcining kilns (35,247-35,251).

According to Thomas Fanning Evans, calcining ceased to be carried out on the mountain some years prior to 1878 (Mining Journal 1878, 943).

Smelting

Only one modern smelting site has so far been discovered on the mountain, a brick-built structure near the eastern perimeter of the Mona mine (30,404), from which a lengthy flue (30,405) runs to the summit of a nearby outcrop. A pile of crucible slag survives nearby (a survey and assessment excavation appeared as Appendix 3 of GAT Report 292).

Whilst there may be other smelters as yet unidentified, it appears that the bulk of the smelting was carried out off-site, mostly at Porth Amlwch or at Swansea or elsewhere. A "Smelting hous" was established in 1770 - where is not known - which may not have lasted, as Thomas Williams struck a deal for the ore to be smelted at Ravenhead on the Mersey and at Upper Bank works in Swansea. In 1797 Mona and Parys were making joint use of thirty-one reverberatory furnaces, which may represent the peak of their activity (Hope 1994, 44-8). The Mona mine abstracts of dead capital for the years 1818 to 1837 record between sixteen and eighteen furnaces, valued variously at £90 and £60, at work at any one time. In 1827 ten new furnaces valued at £80 each are recorded as having been fired for the first time (BU Mona Mine, 2636), but the dead stock accounts for the 1860s show by how much things had declined. The "Furnaces, Roasters, Kilns &c" were valued at £1,630 in 1867, but otherwise they only refer to three furnaces at £80 each, as well as the calciners (BU Mona Mine, 2025-9).

The precipitated copper removed from the precipitation pits needed little treatment beyond drying in specially constructed furnaces before being taken to the smelters. Several buildings to house these furnaces survive, including one at Dyffryn Adda, in existence by 1824 (BL Cartographic Items Maps 6135. (1.), which preserves the reverberatory furnace itself, and which appears to have remained in use until perhaps 1958 (35,587). Others survive roofless and heavily dilapidated. Little documentation survives for them, though one of the mine captains noted in his diary for 1841 that he was trying new furnaces at Dyffryn Coch (LlRO W/DC/27, entry for 22 April). However, the precipitation system resulted in a number of other useful products.

Ochre was extracted from the spent water from the precipitation pits by being agitated whilst still in the final pit, and then diverted into large ponds, where it was allowed to stand. It became further oxidised by exposure to air and settled as a fine yellow precipitate. It was redirected several times to different ponds and the ochre was drained before being taken to covered drying floors. It was dried out by coal-fired kilns, and then carted away to be ground off-site. It is unclear whether this process took place in the same furnaces as were used to dry the copper precipitate.

Spent iron sulphurate water was also used to make sulphuric acid, a substance which continued to be called vitriol even after it ceased to be made from green vitriol. A works had been established at Trysglwyn by 1793, when it is noted by Aitken, and it was leased in 1803 to Dr Joshua Parr, a manufacturing chemist from Carmarthenshire, and it is marked in 1824 (BL Cartographic Items Maps 6135. (1.). The works seems not have functioned in the period 1817-1818, but it is again marked on a map of 1835. The sulphuric acid was used to make pigments and dyes. This site is extremely overgrown, and is only visible as a series of shallow pits and piles of leached spoil.

Mynydd Parys in its Modern phase of operations harked back to methods that had been current in the sixteenth century. There was little mechanisation, and very little use of such common techniques as power-crushing and buddling. Instead the mines relied for over a hundred years on simple low-cost

systems, involving hand-cobbing and slow calcination.

5.3 Power systems

5.3.1 Pre-Modern

No evidence is known to survive for pre-Modern power system on the mountain.

5.3.2 Modern

Both the Mona and the Parys mines made consistent use of human and animal power, intermittent use of wind and of steam power, and limited use of water.

Human and animal power

Early illustrations of the mines show windlasses perched on flimsy platforms on the edge of the opencasts, hauling kibbles and sometimes men on hemp ropes. As an example, “Turn Trees Rolls & Stages” worth £17 13/- are recorded at Mona Mine in 1788 (BU Mona Mine, 3040) and three “hand-whimseys” are recorded at Parys mine in 1815 along the edge of the opencast (BU Bangor 31602). Such devices survived to haul up shafts for many years, but by their nature leave little physical evidence. Timbers protruding from the top levels of the Great Opencast may be remains of one of the platforms (PRN 35421). A feature on the mountain which shows evidence of having depended on human muscle alone is the capstan pit associated with the Pearl shaft, which would have been used for raising and lowering sections of pump-rods when repairs were being made (35,323). This feature has recently been restored with grant-aid from Cadw.

A number of horse-gin sites were noted in the course of the survey, all of them the “whim-gin” variety, in which the horse circle is to one side of the shaft rather than around it. They are seen most clearly in association with the capped Charlotte shaft (35,277-35,278) where it is surrounded by a low bank and with shaft (35,438-35,439). No pivot stones survive. Gins were clearly once very common, and were being installed as late as 1880 (Mining Journal 1880, 374). They were used not only to raise ore but also to raise water. An account of the Parys mine written in the early nineteenth century, looking back at the period 1753 to 1790, refers to water to be used for precipitation being “work’d up by engine” (UWB Mona Mine 3544 fol. 14r), a word which at the time is as likely to mean a pump or a horse-gin as a steam engine, and may refer to a shaft at the south-western extremity of the Great Opencast referred to in 1854 as the “water whimsey shaft” or “south engine shaft” (though known colloquially as twll drwg, “the bad pit”), from which water was ducted to the Parys precipitation system (35,412). It is marked on the earliest Parys map, dated 1815 (BU Bangor 31602). Possibly a gin operated a pump, an unusual arrangement, though not unknown.

A timber jutting from the edge of the Great Opencast may be remains of one of the platforms used for hauling up ore (PRN 35421)

At the Mona mine horse-gins raised water in kibbles; the wages abstracts record payments to partnerships for raising water until June 1846 when they cease (BU Mona Mine, 109), probably as a consequence of installing a steam engine at Carreg y Doll shaft, which first appears in the records the following month (BU Mona Mine, 109).

Wind power

The Mona mine stock-list of 1788 refers to pumps valued at £22 18/- and “water shafts”, presumably a rising main (BU Mona Mine, 3040), which may have been powered by a windmill, since the same source includes a “wind engine” valued at £178 13/-. A windmill - and there may have been several in the late eighteenth century (Pennant, 279) - is depicted in John “Warwick” Smith’s watercolour of 1785, a small tower mill with vertical walls, believed to have been demolished by 1790 (Guise and Lees 1992, 138-9). There is an obscure reference to “fixing air machine at New shaft” in 1836 (LIRO W/DC/26, entry for 15 August 1836), which may be interpreted as a wind-pump rather than as a fan, but otherwise nothing more is heard of wind-power until 1878, when the Cairns shaft windmill was built (Cockshutt 1960, 18).

This impressive feature is the single most prominent landmark on the mountain, and is visible over a con siderable distance. It is a stone-built conical tower mill, which measures 8m in diameter across the

base and stands approximately 20m high. Uniquely for Anglesey, it was a five-sailed mill; the cap and all the machinery are missing, but it is believed to have contained an upright shaft driven by bevel-gearing from the sail-shaft, which in turn operated 200' of flat-rods by means of a crank in its foot. The flat-rods operated a pump in Cairns' shaft, and were supported on intermediate dolly-posts. The windmill was still operating in 1901 (Guise and Lees 1992, 137). The wind-pump aided a steam engine at Cairns shaft, though as the base of the windpump is buried buried by clinker it is thought the steam engine continued operating after the windmill had gone out of use. Its importance as the only surviving pump-windmill in an extractive metal industry in Britain was recognised by scheduling as an Ancient Monument in 1995. Works were undertaken in 2012 to stabilise the structure, and two internal floors have been added. The masonry was recorded by RCAHMW, and a wider survey undertaken by GAT (GAT 2010, Report 859).

Cairns shaft windmill before restoration works (SAM An 111a; PRN 3497)

Steam, gas and air power

The earliest attempts to use steam power at the mines seem to be in the latter years of the eighteenth century. A Boulton and Watt winding engine was installed at the Parys mine to wind in about 1790, but to have seen little use owing to the problems of the cupriferous water damaging its iorn components (Bennett and Williams 2000, 40-41). Steam winding engines had only been in use since the early 1780s, so Parys was early in the field (Dickinson et al, 162-3). Its site may be indicated by the stone retaining wall on the north side of the Great Opencast, where cinders have been found in the grass (35,416), though it is clear that portable and other steam engines were in operation at Parys mine, possibly hereabouts, in the nineteenth century.

When Thomas Williams petitioned for the duty on coal delivered by coast to be suspended in 1786, one of his reasons was that by "reason of the increasing depth of the said Mines, and the Situation of the Ore, it will be impossible for the Water to be kept out of them without the help of Fire Engines" (J. Rowlands, op. cit., pp. 35-6, UWB Welsh Library Rare Books X/KF 379 PAR, An Act for Allowing a Drawback upon Coals used in smelting Copper and Lead Ores, and in Fire Engines for draining Water out of the Copper and Lead Mines, within the Isle of Anglesey (26 George III cap. CIV), even so, no steam pumping engine was to be installed until well into the next century.

This was the Cornish engine to pump the already existing Pearl shaft, installed in 1819 in a purpose-built engine house, believed to be the oldest surviving example in Wales (Bennett and Williams 2000), and Scheduled as an Ancient Monument in 1995. It has recently been consolidated by AIHT with grant-aid from Cadw and as part of an HLF grant. A slate roof has been put back on, and the boiler chimney has been rebuilt. The engine was purchased by the Mona mine from Neath Abbey ironworks in 1819, and installed on the north-eastern perimeter of the site that year, where it replaced a horse-gin (UWB Mona Mine 280). The Neath Abbey Ironworks papers in the West Glamorgan Record Office contain plans for an 18" engine for an unspecified Anglesey firm, dated 1818 to 1820 (D/D NAI/M 10/1-6, 246/1-3). Advice concerning an engine dated 17 July 1818 from Joseph Tregelles Price (of Neath Abbey Ironworks) is recorded in UWB Mona Mine 232, and payment of the balance owing for an engine (£387 12/2d) to the same individual is recorded in UWB Mona Mine 304, dated 5 May 1819. It first worked on 27-30 March 1819 (BU Mona Mine 288-30). Faraday describes it as "a small steam engine employed to drain one of the workings of the mine ... good and preserved in very neat order within the house, the outdoor parts were of timber" but adds:

"The miners found themselves at first very much embarrassed in working this engine in consequence of the peculiar nature of the waters in this neighbourhood. For being a solution of sulphate of copper they acted on the cylinder and other iron parts of the engine rapidly corroding them and rendering the whole useless. Now they very carefully collect the waters from the higher parts of the mountain where they are more free from sulphate of copper, and they neutralise what portion of that salt may be in them with the acid also that they contain by lime and they also preserve the condensed water and cooling it in reservoirs they use it again." (Tomos 1971, 79).

Effective though lime, and chalk, which they had also been using, may have been, it was not long be-

fore Treweek was on the look-out for cheaper ways of neutralising the acidity of the water, as they were costly and could not be recycled (BU Mona Mine, 293, 295). This engine powered a lifting pump and a forcing pump in a 360' (Pearl) shaft (Tomos 1971, 85-6). The original pumps were of iron, for which wooden pumps with brass moving parts had to be quickly substituted (BU Mona Mine, 292, 294).

A French visitor of 1826 appears to be referring to this machine when he describes the mine as dewatered by "une seule machine à feu, de la force de 6 chevaux, placée à quelque distance de la grande ouverture." (Victor-Frère-Jean, op. cit., pp. 229-238). How long it remained in use is doubtful, for the Mona mine wages lists, which survive from 1822 onwards, consistently refer to the steam engine department until 1829, and the accounts refer to men working on the steam engine until March of that year, suggesting it was taken out of use then, and a curious reference of 1819 suggests that the engine was only intended to work for ten years (BU Mona Mine, 232). By 1833 the abstracts of dead capital refer to it as "old steam engine", possibly to distinguish it from a new arrival (BU Mona Mine, 167). In 1853 a 24" engine was bought from the Perran Foundry through Messrs Hocking and Loam of Redruth, consulting engineers, for a total of £632 and installed in the Pearl engine house (BU Mona Mine, 2786), but it was not long before it needed attention, for the spring beams were observed to be rotten in 1857 and had to be replaced (BU Mona Mine, 2787). It was still at work "in an efficient manner" in 1880 (Mining Journal 1880, 134). Though commonly referred to as the "pearl engine", Owen Griffith calls it "ingian Cerrig y Bleiddiau." (Griffith 1897). It was valued at between £820 and £750 between 1865 and 1870 (BU Mona Mine 2025-2039), suggesting that Hocking and Loam only supplied some parts of the machine, and that a number of components remained from the previous engine.

Pearl Engine House in 2008 after the first restoration works

To the south of this feature is a heavily dilapidated and overgrown structure (35,340) which may also have been an engine house (though has also been described as a mine office, or house), and which lines up with a row of substantial pillars (35,331) leading to a pump in Treweek's shaft (35,327). A stone wall (35,329) formerly supported a launder which carried the mine water to the precipitation pits at Dyffryn Goch (Bennett and Williams, 2000, 44-5; GAT 2010, Report 859).

Another steam engine arrived in, or by, 1834, evidently a small affair, for it was valued at no more than £425 (UWB Mona Mine 167). What function it served is not clear, but there is a reference to steam power in a mine captain's diary for 1836 ("at Port saw Mr Treweek there Mr Scott, & Harrison & R.M. Jones about Steam Engines", LlRO W/DC/26, entry for 12 September 1836) and there are scattered references to "engines" in a mine captain's diary for 1841, in contexts that suggest that these were not all of them necessarily pumps - one of them, for instance, suffered a broken crank (so clearly a rotative engine), and another had to have water carted to it. A "surface engine", an "underground engine" (possibly in Carreg y Doll chamber) and an engine in the opencast are noted in 1841 (LlRO W/DC/27, entries for 11 and 12 January, 6 February, 30 July, 3-5 August, 27 September, 1 October 1841), suggesting that there had been more than one arrival in the 1830s. The "surface engine" may have powered an uphaulage incline from the opencast.

The overgrown remains of a small engine-house (242) for pumping the Carreg y Doll shaft at the Mona Mine (241) probably date from July 1846 when workmen were paid for carting water to the engine (UWB Mona Mine 109, entry for 4 July 1846), which was valued at £250 in the 1860s. In 1860 the unfortunate Captain Tiddy took refuge in the engine house from the workmen during a strike meeting, only to find that the engine's wheels broke loose and shattered over him whilst the building shook to its foundations (Griffith 1897, 60). The engine here was patched up and supplied with a new boiler in May 1865, but the want of a powerful unit was still felt (Cockshutt 1960, 17). The Carreg y Doll shaft at the Parys mine also acquired a steam engine for winding at some stage; a photograph shows corrugated iron buildings and a timber headframe here (Hughes 1987); it is likely that Tiddy's discomfiture took place at the Mona mine site, not, as Mr Hughes suggests, at the Parys Carreg y Doll shaft, since it is clear from Owen Griffith that the engine in question was being used for pumping, and the Parys Carreg y Doll shaft, on the evidence of Trem

yn Ol, is clearly an uphaulage shaft.

A steam winding engine at Mona mine's "New Shaft" (Cairns) (PRN 35,307) is recorded in the period 1865-1870, valued at £260 (BU Mona Mine 2025-9). Pumping this shaft was carried out by the windmill (3,497) in the 1880's, once it had become clear that the Carreg y Doll engine was not capable of dewatering this part of the mine by itself, but the need of a more powerful engine was felt, and a pumping engine came to be erected at the head of the Cairns' shaft. Its site is marked by a substantial stone base and twisted holding-down bolts (35,308); it is possible on the evidence of the site that the engine itself was a differential compound, such as were frequently advertised in the Mining Journal at this time. The engine was manufactured by the Sandycroft foundry on the river Dee, and first steamed on 8 December 1880; it took the labour of seventeen horses to drag the boiler to the top of the hill (Mining Journal 6 November 1880, p. 262, 11 December 1880, p. 1418).

The inclined plane out of the Hillside opencast had a steam engine by 1852 (Vernon 1996, 44; BU Mona Mine 3358), valued at no more than £50 to £30 in the 1860s stock accounts, suggesting that it had been there in 1841 for the Captain to refer to in his diary. In 1889 a "new engine" is noted at the summit of the plane from the Hillside (BU Bangor 31590). The possible site of such a machine was noted in the course of the present assessment, (35,458) but the incline itself appears to have degraded.

Absalom Francis, in his report on the mine in 1880, refers to a 16" winding engine "which draws from three main shafts by means of a vertical drum" (Mining Journal 1880, 134) which Cockshutt appears to gloss as the Calciner engine, operating Black Rock (35,460), Tiddy Newydd (35,334?) and Job (35,436) shafts, as well as the Calciner shaft itself (35,466) (Cockshutt 1960, 23; Greenly 1919, 842). It is possible that this engine also powered whatever machinery was installed in the calciner itself (35,463), though the suggestion that it bored wooden pipes and drums is not borne out by the archival evidence, which suggests that this was done by the Cairns' shaft winder (Mining Journal 1880, 134; Cockshutt 1960, 23).

At Parys mine the first steam engine after the unsuccessful Boulton and Watt winder was Ingian yr Open Cast Mawr (35,413), which, as its name suggests, was situated in the great open cast, and which operated Marquis pump-shaft. This machine was in existence by the 1850s, when it is shown in a water-colour by the mines inspector Warrington Smythe (Vernon 1996, 43).

Ingian yr Open Cast Mawr (PRN 35413)

A pumping-engine was installed on the Morfa Du shaft in 1872-3 (35,566, 35,567) (Mining Journal 23 November 1872, p. 628, 17 February 1872, pp. 142-3, 6 January 1872, p. 6).

One other heat engine used on the mountain was a gas suction engine (35,546) at Ty Main which drew water out of the Dyffryn Coch precipitation system through an enclosed pipe (35,549) across the Hillside area to sparge the head of the tips near the Cairn's shaft (Cockshutt 1960, 23).

Some use was made of compressed air. The Sandycroft foundry quoted Parys mine for a compressor "to be attached to the back of our engine" in 1878 (HRO D/DM/279/1. The building over the footway entrance at the mouth of the Parys mine footway (35202) has been identified as a possible compressor-house, and archival references make it clear that a Dunne's boring machine was in use in 1881 (Mining Journal 1881, 504). Iron piping to carry the compressed air can be found underground in the Parys 16fm level and in the Mona +12fm level.

Water power

Very little use was observed to have been made of water-powered machinery. The one water-wheel recorded as associated with the mines, (35,311) at Tal Dyffryn, appears to be marked on the map of 1815-1819, and a painting (copy in possession of Bryan Hope) of the house shows that it operated a pump shaft (35,312) by means of flatrods and angle-bobs. Absalom Francis' report states that it was used to pump water to the steam engines (Mining Journal 1880, 134).

A "water engine with appurtenances" is noted at the mines in the period 1865 to 1870 (BU Mona Mine 2025-9), probably a water-pressure engine to pump lower levels (i.e. greater than 45fm), since it is unlikely at that stage that a pump would be

called anything other than a pump. No evidence was observed of this feature, but it is possible that it was situated underground in Carreg y Doll chamber where wooden pumps can be found.

The location, topography and, unusually, even the geology, of Mynydd Parys were determinants of the power systems used. Its exposed situation encouraged the use of wind-power, and the problems of arranging a fresh water supply discouraged the use of steam. However, its hill-top location ruled out extensive use of hydraulic power, such as was a feature of most other metalliferous mines in Wales, and the mines were forced to use steam winders and pumping engines once the task became too arduous for horse-gin and windlasses.

5.4 Transport systems

Lon Goppa'r, looking north (PRN 35318)

5.4.1 Pre-Modern

No evidence was observed for pre-Modern transport within the study area.

5.4.2 Modern

The ore is recorded as having been moved by hand, by barrow, by cart and by internal narrow gauge railway.

Early paintings show wheelbarrows being used in the opencast, and Owen Griffith quotes Llew Llwyfo (Lewis William Lewis, the future novelist and impresario) in his old age remembering how as a boy he would wheel a box-barrow down to the assay office (W. Havell, The Great Opencast (in possession of the Most Hon. the Marquess of Anglesey), Griffith 1897, 39). It is also clear from the substantial roadways that connect the different parts of the mines that many internal movements were carried out by cart, and throughout its modern history the mine made use of horses and carts to transport ore to Porth Amlwch as well as for back-carriage of coal, bricks and other necessaries. Previously, in the 1760s, Roe and Company were paying miners 3d a bag of ore delivered at the port (BU Mona Mine 3536); but after they left, the Mona mine built a road to the port in 1788 (BU Mona Mine 3040). This is the Lôn gopar, (35,318), a remarkable example of an eighteenth-century industrial road, described after it had been in use for thirty years as "a very dusty, dirty road for when bad it is mended with slag and as there are always 12 or 14 carts moving backwards and forwards on it these materials are soon ground into black and disagreeable powder" (Tomos 1971, 78). From perhaps 1811 onwards William Hughes of Madyn Dysw near Amlwch held a monopoly of carting for them, whilst Parys Mine, which built its own road at an uncertain date, relied on a number of local farmers (Rowlands 1981, 73-5). A proposal to construct a railway from both mines went as far as commissioning C. B. Vignoles, the distinguished civil engineer, to survey a route to the port, and a short length of railway, including an incline powered by a steam engine, was, as noted above, in existence between the port and the smelters by 1834 (BU Mona Mine, 3285). This was 2' 6" gauge, and the rails survived on the quay until recently (Pers. Comm. Bryan Hope). Though work began on the link to the mines themselves, and the plan was still being discussed as late as 1863 (BU Mona Mine 1051, 1550, 2792,) the ore continued to be carried by cart for as long as mining lasted.

Internal railways were on a small-scale; Faraday, writing in 1819, remarks "There are no trams used on these roads or in the mines in consequence of the corrosive effects which the waters from the workings would have on them and which would destroy them in a short time" (Tomos 1971, 78). By September 1827, however, a number of the Parys mine tributers were making use of short lengths of railway, almost certainly unconnected to each other (LlRO: WDAP3, cost-analysis of Parys mine, 3 September 1827). This may reflect the fact that the previous month the mine had purchased nearly two miles' worth of cast-iron plate rails at the bargain price of £4 a ton second-hand from the Nantlle Railway (UWB Mona Mine 2636, Boyd 1986), but it is equally possible that the plates were purchased as scrap for the precipitation pits or to build a railway to the port, though Vignoles had strongly recommended wrought-iron edge rails. A photograph published in Trem yn Ôl shows lengths of bridge rail at the head of the Parys mine Carreg y Doll shaft (Hughes 1987, 55), and a chair discovered on site for bar-rail is in possession of the AIHT. An incline plane from the Great Opencast was in existence by the 1850s (35,707), and one from the Hillside by 1852 (BU Mona Mine 3588). A map of 1889 marks a "new

engine" at the summit of a plane from the Hillside. In a number of places, such as south of the Charlotte shaft and at the summit of the Great Opencast incline, tips appear to have grown in a way that suggests the use of railed wagons, possibly side-tipping. Remains of sleeper impressions can be seen in the surface east of the Mona opencast (35,702), and several bored limestone sleepers have been found on the mountain. There is also evidence of sleepers underground in the Parys 45fm level.

Mynydd Parys was therefore unusual by the standards of most industrial undertakings of the Modern period in making very little use of railed transport, and in depending to a great extent on road vehicles.

5.5 Drainage

There are many open and culverted drains on the mountain, used to move water around the mountain. Supplies of fresh water were required for the steam engines, whereas copper rich water drained from the mines was fed into precipitation ponds. Sparging was undertaken on areas of the ore tips; and ore was washed and the water then taken for precipitation. The drains and culverts on the mountain have not been fully mapped, however a knowledge of their location and purpose is essential for a full understanding of the working of the mines. One early drain, pre-dating the Great Opencast, was discovered during excavations for the footpath being laid between the two opencasts, and similar exposures below modern spoil have been noted at Mona footway and spoil 200m SE of the mines road entry (Jenkins 2014). Other drains and culverts were excavated during the Henwaith watching brief (GAT 2011, Report 914).

An example of variation in the colour and form of the tips on Parys Mountain.

5.6 Waste mineral and quarrying tips

A high proportion of the surface of the mountain is made up of waste tips. These provide a range of rock types and also display a wide range of yellow-red-brown colours from the oxidation of iron released by weathering of the abundant waste iron pyrite, and support mostly only heather due to their acidity. Whilst these have significant geological and mineralogical research potential, the variation in the tips also reflects differing processing and smelting techniques, and so provide potential for greater archaeological understanding. No significant mapping of the tips has been undertaken.

5.7 Ancillary structures

5.7.1 Pre-Modern

No evidence was observed for pre-Modern ancillary structures.

5.7.2. Modern

John 'Warwick' Smith 1792 View of the Mona Mine Yard (National Library of Wales)

Ancillary structures connected with both the Parys and the Mona mine survive at various locations. Very little remains of the Parys mine yard (35,417), which is shown on the 1815 map (BU Bangor 31602), and rather more of the Mona Mine yard (35,522) in 1786, when it is described as "New Yard" (BU Bangor 31603). Both are quadrangular arrangements with a cart-entrance in one wall. The Mona yard was described by Owen Griffith in 1897 as containing a smithy, lime-store, wagon shed, furnace, carpenter's shops, assay office, stables, a turnery shed for producing the wooden piping and a place for the bier. He records that at the turn of the eighteenth and nineteenth centuries the then mine manager took it into his head to demolish the chapel at Rhos y Bol, and that the pulpit found its way to the Mona mine yard loft (Griffith 1897, 15-16). Whilst the variety of buildings is typical of a large metalliferous mine, the enclosed yard is unusual. The Mona

yard is clearly shown in a painting by John "Warwick" Smith (1792, British Museum) which shows a tall three-storey range on the west side, and a bell house to the south. Measured surveys of both yards have been undertaken (GAT 2009, Report 788).

In common with any sizeable mine, Mynydd Parys had a number of smithies. The main Mona smithy (35,402) lay near the eastern limit of the Great Opencast, and it was this which Owen Griffith describes as the scene of the mine's regular preaching meetings (Griffith 1897, 53-7). A smithy is marked on or near this site as early as 1786, as well as "Sir Nick's smithy" near the Parys boundary, and a smithy which lay perilously close to a fresh collapse (BU Bangor 31603). A valuation of Mona mine in 1788 refers only to the "upper smithy", possibly because the lower smithy had collapsed or prudently been demolished in the interim, and its functions already transferred to the New Yard. The assay office was also threatened by a collapse in this period. The Brimstone yard (Iard brwmstan) (35,269) is marked on the Parys mine map of 1815 (BU Bangor 31602); its site is heavily overgrown due to weathering of the buildings' mortar lowering the soil acidity, and little can be made out of the arrangements which prevailed here.

5.8. Domestic buildings

5.8.1 Pre-Modern

No evidence was observed for pre-Modern settlement associated with the study area.

5.8.2 Modern

"Cabins" valued at £23 17/- are noted on the 1788 Mona mine valuation, which may be represented by the perspective drawings of two room dwellings on the 1786-8 map. One of the falls is described as "back of Mr Roose's house", either the dwelling of Jonathan Roose who "first yon mountain's wondrous riches found" or of one of the prosperous dynasty he established, implying that workers of several different grades built dwellings in an ad-hoc fashion on the mountain (BU Bangor 31603; Mona Mine 3040). However, none is marked on the Parys map of 1815.

Some domestic structures are noted in the nineteenth century at various locations within the Mona mine. In Dyffryn Coch there stood the remains of ty Cadi Rondol, "Catherine Randles's house", a famous local character converted from a life of sin by John Elias himself, and next to it the house of the steward who looked after the precipitation pits (Griffith 1897, 71-7). The dwelling Fron Heulog (colloquially Ty Main) was the home of the man responsible for the gas engine (Cockshutt 1960, 23).

5.9 Commemorative features

5.9.1 Pre-Modern

No commemorative, ceremonial or ritual features appear to be associated with the site before the Modern period.

5.9.2 Modern

At least two rock-cannon were drilled , at the E end of the Great Opencast on Mynydd Parys (features 38 and 39, GAT 2010 Report 1198) to celebrate the coronation of King George IV in 1821, when the newspaper report notes "We are happy to have to add, that the whole passed off without any serious accident; two men were scorched in their faces with Gunpowder, rather badly, but not so as to endanger the sight of either of them", and the occasion was also marked by cutting the first sod of the Coronation shaft (North Wales Gazette 26 July 1821; Jones 2002); these cannon or others were fired in December of that year to celebrate the birth of a son and heir to Colonel Hughes (North Wales Gazette 26 July 1821). The coronation of King William was celebrated by a feast in the Oxen quarry, attended by 1,400, at which "a moderate but sufficient allowance of ale to prevent all excesses" was offered (Hope 1994, 64).

One of the rock canon in the Great Opencast (PRN 35731)

Edward Pugh 1790, Parys Mines (National Library of Wales). Several buildings which may be dwellings are shown on the mountain.

6. ASSESSMENT OF SIGNIFICANCE

6.1 Introduction

The Mynydd Parys copper mines constitute an archaeological resource of the utmost importance not only within a British archaeological context but internationally. Their scale and the impact they made on the world copper industry from 1768 to the end of the 18th century establish their historical significance, and the wealth of underground and above ground remains confirm their archaeological significance. This section draws on the information presented in the historical and archaeological summaries above to provide a more detailed assessment of their significance. Landscape significance is examined first, then prehistoric mining, followed by post-medieval mining. Individual Statements of Significance are then given for particular features on the mountain. Significance is discussed in terms of historical/archaeological survival and its national/international context; the level of contribution to modern research; and its social and community potential.

6.2 Statement of significance: the landscape

The landscape was considered to be of National significance in 2005, when considering the wider historic landscape to include Amlwch and Porth Amlwch (Gifford and Partners 2005, 44-5). The principal characteristics considered were the 'intensive Modern-period industrialisation within a context that was otherwise rural', and its economic and technological links with Swansea.

The landscape is considered to be of international significance for:

- The unique and dramatic environment of the mountain, including the exotic colours of the tips, the distinctive natural environment, and the vast great and smaller hillside open casts
- The survival of visible nationally significant archaeological features
- The ability to appreciate the 'Sublime' as recorded by the late 18th century artists
- The visual relationship between sites of extraction and processing on the mountain with transport routes to the port and settlement of Amlwch and Porth Amlwch
- The relatively undeveloped nature of the surrounding agricultural landscape, which remains little different to that which existed when the mines were operating

The landscape is of international historic significance as a source of evidence for/knowledge of:

- The potential for greater understanding of the prehistoric landscape
- The inter-relation of the full range of extraction, processing, transport and ancillary processes associated with a late 18th century/19th century copper mine of international reputation

The landscape is of social and community value as:

- An open space which is readily accessible
- As a colourful and visually striking industrial landscape
- A place which connects the town of Amlwch and the settlement at Porth Amlwch with its past
- As part of the rich historic landscape of the wider area
- For its recreational possibilities
- For its educational and scientific potential

The 'unique and dramatic' landscape of Parys Mountain

6.3 Statement of significance: prehistoric and early historic mining

Summary history

The 2005 Conservation Management Plan identified the underground Bronze Age remains as internationally significant. A recent review of prehistoric mining in the UK and Ireland identified nine areas of known copper mining, all within western Britain and Ireland (two located on the Isle of Man). The mines furthest west were at Mt Gabriel and Ross Island on the south-west coast of Ireland, whereas those furthest east are located at Alderley Edge and Ecton (Timberlake and Barnatt in Barnatt 2013, 304-7). The earliest dates so far recovered are from Ross Island (c. 2400 BC), and there appears to be a chronological progression eastwards (ibid. 305). A range of eleven radiocarbon dates from Parys Mountain indicate mining took place between 2200 and 1800 BC (Jenkins *in prep.*). The earliest dates from the Great Orme are after 1900 BC, with mining perhaps continuing until 1100 BC. At the Ecton mines there is no evidence for mining prior to 1800 BC.

No new evidence for mining within the Roman, medieval and early post-medieval periods has come to light despite specific investigation by AIHT. The discovery of direct evidence for Roman mining would be of international significance. The discovery of medieval mining would be potentially of regional significance (Gifford and Partners 2005, 45).

Significance

The Bronze Age mining is of international significance for the way in which it:

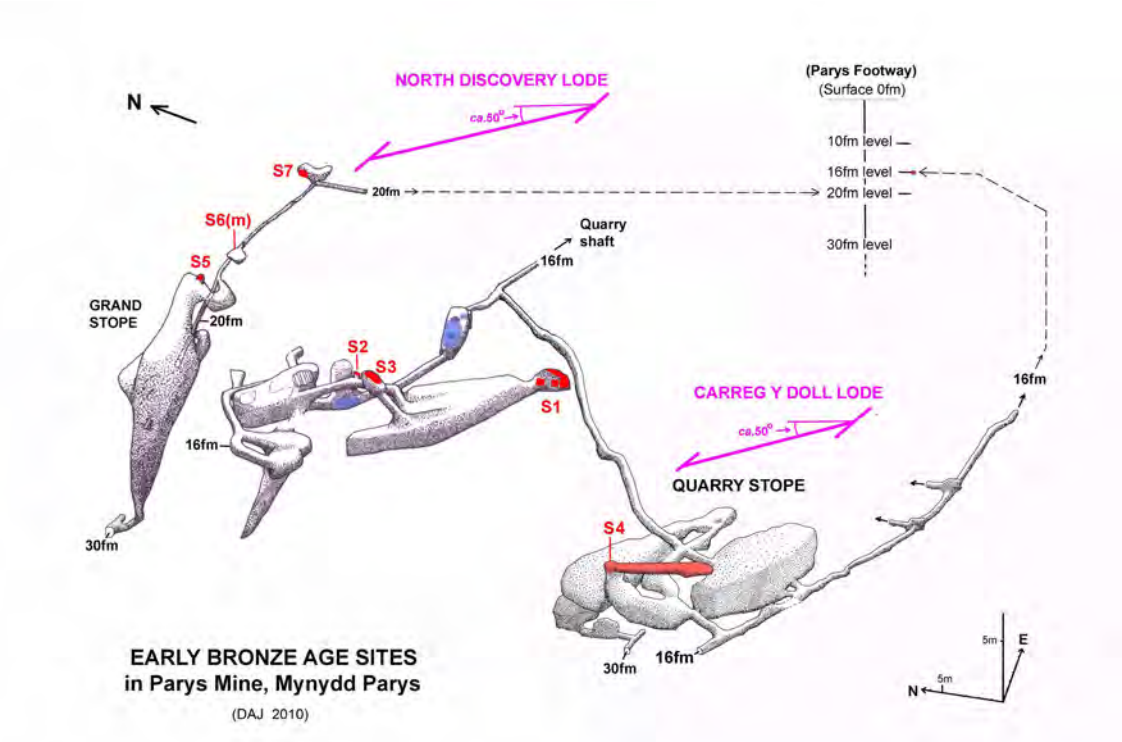
- Demonstrates prehistoric mining techniques
- Provides good chronological evidence for prehistoric mining, with the presence of well-stratified remains
- Contributes to a very small pool of knowledge from other prehistoric mining sites in the UK
- Contains considerable potential for further discovery

The Bronze Age mine is of international historic significance as a source of evidence for/knowledge of:

- Prehistoric mining techniques
- The use of tools associated with prehistoric mining, in particular a wide range of stone mauls, of which 140 have been recorded
- Chronological development of prehistoric mining

The Bronze Age mine is of social and community value as:

- A way to experience underground workings of prehistoric date
- For its recreational possibilities
- For its educational and scientific possibilities



Location of underground Bronze Age workings (David Jenkins 2010)

6.4 Statement of Significance: the great opencast and hillside opencast, Mynydd Parys copper mines

Summary history

The great opencast is a large open quarry in which low-grade copper ore was extracted. It is believed to have been created after the collapse of existing tunnels and shafts in the late eighteenth century. Rock was raised from the opencast variously by hand-windlass, by horse-system operated ropeways, by horse-and-cart and possibly by steam-operated rail incline. The opencast was worked on a very significant scale in the late eighteenth century, and attracted savants and artists who were struck by its sublime immensity. From the early years of the 19th century, the focus of mining moved to deeper underground workings accessed by shaft and footways, and the opencast was little worked. The two opencast quarries are Scheduled as Ancient Monuments (AN111D).

Significance

The great opencast is of international historic significance for the way in which it:

- Illustrates the distinctive nature of working at the Mynydd Parys copper mines at a time when it was the most productive copper mine in the world
- Illustrates the intensive nature of working at the Mynydd Parys copper mines at a time when it was the most productive copper mine in the world
- Illustrates the scale of operations at the Mynydd Parys copper mines at a time when it was the most productive copper mine in the world, and the ease with which the ore could be extracted
- Retains the sense of sublime immensity which attracted savants and artists in the 18th century

The great opencast is of international historic significance as a source of evidence for/knowledge of:

- The extraction of copper ore at a crucial period of the British industrial revolution
- The development of an 'industrial sublime' in art of the late 18th century
- Understanding of mining techniques at a crucial period of the British industrial revolution

The great opencast is of social and community value as:

- As a colourful and visually striking industrial landscape
- A place which connects the town of Amlwch and the settlement at Porth Amlwch with its past
- As part of the rich historic landscape of the area
- For its recreational possibilities
- For its educational and scientific possibilities

The Great Opencast from east

6.5 Statement of Significance: Mynydd Parys copper mine precipitation pits

Summary history

Precipitation of copper by iron in water in extensive shallow ponds ('pits'), often in conjunction with larger and deeper lakes for the extraction of ochre, is attested on Mynydd Parys in 1772. This system has parallels with mining areas in Ireland, England and continental Europe, and it is possible that it was introduced to the mines by Roe and Co. of Macclesfield.

Further ponds and lakes were constructed in the first two decades of the 19th century, and from the 1880s onwards this was the sole method of extraction. The Dyffryn Adda pits were in commercial use until 1958. The Hillside pits and the Dyffryn Adda pits are both Scheduled as Ancient Monuments (An 111C and An 135).

Significance

The Mynydd Parys precipitation pits are of international historic significance for the way in which they represent:

- The development on an extensive scale of a mineral extraction system that has parallels in Ireland, England and continental Europe. The Mynydd Parys examples are the largest known surviving system of copper precipitation pits in the world, and contain the best surviving archaeological evidence for this method of extraction of copper.

They are of international significance as a source of evidence for/knowledge of:

- Technology transfer between different mining areas in Ireland, England and continental Europe

They are of social and community value as:

- As part of the rich historic landscape of the area
- For their recreational possibilities
- For their educational and scientific possibilities

The Hillside Precipitation pits from north-west

6.6 Statement of Significance: Calcining kilns and sublimation chambers

Summary history

Calcining of the copper ore to remove sulphur by burning was carried out on Mynydd Parys from 1770 for about a hundred years. As the system developed, ore was heaped, held in place by larger pieces of ore, holes and flues were constructed, and the whole allowed to burn, the sulphur being collected in adjacent stone-built flues.

The kilns themselves are visible as rounded oval depressions, anything up to 17m long and 6m across, some of which appear to feed into long but barely defined flues and which are associated with sulphur sublimation chambers, visible as parallel stone walls, typically 16m long, 1m high, each 0.8m wide and 0.6m apart. Around the kiln-sites the spoil is a distinctive pinkish colour.

Two main areas of kilns survive, one of the areas is scheduled, but the sites of many others are evidenced by the deep red coloured waste tips scattered over the mountain.

Significance

The calcining kilns and sublimation chambers are of international historic significance for the way in which they:

- form components of a rich archaeological and historic landscape of mining activity
- illustrate the component processes of producing copper and sulphur and other by-products at a major mining site of the 18-19th centuries

The calcining kilns and sublimation chambers are of international significance as a source of evidence for/knowledge of:

- ore-processing methods at a major copper-mining site of the 18-19th centuries
- possible technology transfer with other copper-mining and -processing sites

The calcining kilns and sublimation chambers are of social and community value as:

- Part of the rich historic landscape of the area
- For their recreational possibilities
- For their educational and scientific possibilities

Parys Mine Calcining kiln, from north (PRN 35,206)

6.7 Statement of Significance: Cairns shaft windmill, Mynydd Parys copper mine

Summary history

Wind-power was used at Mynydd Parys copper mine from 1785, if not earlier, to pump and possibly to wind. Hughes, the mine captain, built this five-sail tower windmill in 1878 to augment a steam engine which operated pumps in the adjacent Cairns shaft. It operated into the 20th century. The tower was Scheduled as an Ancient Monument in 1995 and consolidated for AIHT in 2011.

Significance

The Cairns shaft windmill is of national historic significance for the way in which:

- it represents an unusual use of wind-power in the context of an extractive industry
- it represents an unusual example of the late harnessing of wind to power a prime mover to augment an existing steam engine

The Cairns shaft windmill is of national significance as a source of evidence for, and knowledge of:

- the means by which the Mynydd Parys mines were dewatered
- how earlier technologies remained relevant in the steam age

The Cairns shaft windmill is of social and community value as:

- a place where the technology of the past is brought to life by means of display boards
- An important local landmark
- As part of the rich historic landscape of the area
- For its recreational possibilities

Above: The windmill with flatraods in the foreground heading towards the Cairns shaft.

Right: The windmill tower following restoration in 2012.

6.8 Statement of Significance: Mona Mine (Mynydd Parys) Pearl shaft engine house

Summary history

The engine house and adjacent boiler-house and round-plan chimney were built in 1819 to accommodate a beam engine by Neath Abbey Ironworks, built on the Cornish cycle, which was installed to pump water from the existing Pearl shaft. It is believed to be one of the oldest surviving examples in Wales. The engine was replaced, in part or whole, by the Perran Foundry of Perranarworthal in Cornwall in 1853. It operated until the 1880s. The chimney blew down in 1986, and was subsequently rebuilt for AIHT in 2011-12. The engine-house was Scheduled as an Ancient Monument in 1995.

Significance

The Pearl shaft pumping engine house is of national historic significance for the way in which it:

- Is an early surviving example of a house for a steam pumping engine
- Forms part of the outstanding historic mining landscape of Mynydd Parys as a landmark structure

The Pearl shaft pumping engine house is of national significance as a source of evidence for/knowledge of:

- The adoption of steam technology for mine pumping in the early nineteenth century

The Pearl shaft pumping engine house is of social and community value as:

- An exemplar of community involvement in heritage through the conservation of the engine house and the reconstruction of the collapsed chimney by AIHT
- An important local landmark
- As part of the rich historic landscape of the area
- For its recreational possibilities
- For its educational and scientific possibilities

Pearl Engine House and chimney undergoing restoration in 2014

6.9 Statement of significance: Drainage

Summary history

Drainage of mine water, and the channelling of water around the mountain, was crucial for the successful operation of the mines. Primary adits associated with underground drainage include the Dyffryn Coch adit which drained to the south of the mountain, and the Joint Drainage Level which drained to the north. Both fed extensive precipitation ponds. Other early drains have been discovered during recent works (Jenkins 2014). The delivery and storage of fresh water to steam engines was also crucial, as these were quickly damaged by the use of acidic waters from the mines.

Significance

The drainage systems are of regional historic significance for the way in which they:

- Contribute to our understanding of the mining processes on the mountain
- Forms part of the outstanding historic mining landscape of Mynydd Parys as a landmark structure

The drainage systems are of regional significance as a source of evidence for/knowledge of:

- Our understanding of the complex interaction of mining processes on the mountain

The drainage systems are of social and community value as:

- Part of the rich historic landscape of the area
- For their educational and scientific possibilities

One of several buried culverts, seen here emerging south-west of the Calciner building (PRN 35,464)

6.10 Statement of significance: Waste mineral and quarrying tips

Summary history

Waste tips are an inevitable part of the mining process, and though earlier tips are buried by later workings, the type of waste material, its location, and the structure of tips are capable of providing an understanding of both extraction and processing which is unobtainable from any other source.

Significance

The waste tips are of national historic significance for the way in which they:

- Contribute to the mining landscape through their wide range of colours, ecological development and structure
- Provide evidence for different mining and processing activities on the mountain and of the different rock types encountered in their associated shafts
- Preserve buried archaeology within and under the tips
- Form part of the outstanding historic mining landscape of Mynydd Parys as a landmark structure

The waste tips are of national significance as a source of evidence for/knowledge of:

- The location and type of processing techniques used on the mountain
- Preserved archaeology within and under the tips

The waste tips are of social and community value as:

- The primary backdrop to the landscape of the mines
- An important local landmark
- As part of the rich historic landscape of the area
- For their recreational possibilities
- For their educational and scientific possibilities

The nature and colour of the tips reveal the varied rock types and differenet processing techniques

6.11 Summary statement of significance: Post-medieval and modern mining on Parys Mountain

The post-medieval and modern workings of Mynydd Parys are of international significance. This was the world's most productive copper mine in the late 18th century, one which supplied the Swansea smelters with ore on a huge scale. The 'industrial sublime' which attracted painters to the mountain remains evident. It is a rich yet contained historic and archaeological landscape with further potential for discovery, and whilst clearly many individual features are of considerable importance in their own right, it is their interrelationship that makes Mynydd Parys a site of the utmost archaeological significance. Furthermore, this landscape extends beyond the mountain itself, to include the town and port of Amlwch. Whilst the various methods of extracting the ore at Mynydd Parys have their parallels elsewhere in the archaeology of copper mining, they have to be sought far afield. No other copper mine site in Britain made use of opencasting to the same extent as Mona and Parys, and precipitation is only found at a small number of sites, none of which retain the detail and extent of archaeological remains found on Parys Mountain.

7. CONSTRAINTS, PRESSURES AND OPPORTUNITIES

7.1 Introduction

Significant developments have taken place since the production of the 2007 conservation management plan, many of them identified within that plan. The works include the conservation of the windmill tower; the development of the heritage trail and the new shortened route created by the walkway along the ridge between the two opencasts; the conservation of the Pearl Engine House, and rebuilding of the boiler house chimney. Other conservation and interpretation works have been undertaken at Porth Amlwch. These works have been sympathetically carried out, and make a significant contribution to visitor experience whilst not detracting from the essential values of the site. Survey and limited excavation on the mountain has continued to contribute to our understanding of the remains and their significance. This section will examine the current constraints and pressures on the resource, and will identify opportunities for further protection and development.

7.2 Landscape

7.2.1 External views

This section considers the pressures on external views of the mountain. As discussed above, the primary views tend to be internal, that is, the heritage aspects of the mountain are best experienced from on the mountain itself. However the relationship between the town of Amlwch, its port (Porth Amlwch) and the mountain is a crucial one, and the visual links between them need to be retained. The land drops relatively quickly from the 147m mountain summit to the coastal plain varying between 60m and 30m in height. The town lies approximately 1.2Km away from the lower edge of the mountain. The relatively flat plain separating town from mountain has been developed on the south side of Amlwch by modern housing, some industrial units, and the school. Nonetheless, given the vertical ratio of the mountain to the coastal plain, the mountain is a continuous visual presence from the town, though little detail is visible at this distance other than the iconic reconstructed Pearl engine house and chimney. Similarly the town of Amlwch is clearly visible from the north side of the mountain, though again little detail is visible.

The mountain ridge is aligned ENE-WSW, and is most clearly visible from the north-east and south-west.

Pressures

- Further development between the town and the mountain, if at an inappropriate scale, will obscure visual relationships between the two.
- Development north-east of the mountain (between the A5025 and the mountain) will have a detrimental impact on some of the best external views.
- Development south and west of the mountain will impact upon views from the Llanerchymedd road (B5111) and also upon the view from the prehistoric round barrow.
- The windfarm south of the mountain is an example of modern development which has a detrimental impact upon the setting of the mountain. However the present scale of the turbines does not result in a high negative impact, though an increased change in scale, density or area would certainly do so.

Opportunities

- Develop a viewing spot from A5025 east of mountain with interpretation/information.
- Planning decisions should reflect the international significance of the site, and its designation as a Landscape of Outstanding Historic Interest.
- Make greater use of the ochre ponds as features of both heritage and natural interest

7.2.2 Internal views

Pressures

- Vegetation growth is obscuring many features due to decreased aciity by building mortar.
- New visitor developments must continue to be carefully designed to avoid negative impact on the landscape.

Opportunities

- Identify views of 18th century artists and use modern technology to superimpose images on to present-day landscape
- Work with NRW to manage vegetation growth

7.3 Prehistoric and early historic mining

It has not been possible, within the remit of this report, to assess fully the significance of the underground workings, which is where the primary prehistoric evidence lies. Its importance is, however, discussed above where it is recognised as being of international significance. The following pressures and opportunities reflect the limited assessment

undertaken. A full assessment of the underground remains is necessary before these can be expanded upon. Only one above-ground site has been identified.

Pressures – above ground workings
- Lack of knowledge of the whereabouts of sites means they cannot be appropriately managed.

Pressures – underground workings
- Danger from flooding preventing access to lower areas
- General difficulty of access, particularly for general public. PUG currently arrange visits and insurance for visitors.
- Increased visitor pressure could result in increased erosion of archaeological layers
- Natural underground rock falls and slippages which prevent access and obscure features

Opportunities – above ground workings
- Identify additional prehistoric sites by investigating those areas where stone mauls have been found on the surface
- Use on-site interpretation to explain the significance and extent of the prehistoric workings

Opportunities – below ground workings
- Develop a recording and conservation framework for underground remains
- Develop an underground tour for visitors (though finding suitable insurance is a problem)
- Undertake full assessment of below ground workings
- Use new enhanced surveying techniques to record underground data
- Potential for underground statutory protection.

7.4 Post-medieval mining and processing sites

This section considers the archaeological remains located on the mountain which post-date 1768, when mining was resumed at a significant scale.

Pressures
- Many of the features are not easily identifiable to the casual visitor, and are vulnerable to foot damage. The precipitation pits and sulphur kilns are typical examples.
- Vegetation growth is obscuring many features largely due to decreased acidity by building mortar.
- Motorbikes and quad bikes are able to gain access to the site, and are having a detrimental impact on the archaeological remains.
- The furnace site (PRN 30404) excavated in 1998 is heavily overgrown and is now difficult to interpret.
- The condition of the reverberatory furnace at Dyffryn Adda is deteriorating

Opportunities
- Improve statutory designation to aid protection and management of sites
- Emphasise the unique heritage survival of the site through enhanced interpretation, and in particular draw attention to the vulnerability of the features.
- Excavate and expose one of the sublimation kilns to aid interpretation
- Clear and interpret the smelting site (30,404) excavated in 1998.
- Create a full record of the Dyffryn Adda furnace
- Conserve the Dyffryn Adda furnace and buildings
- Conserve the precipitation pits at Dyffryn Adda
- Examine the potential for a field study centre at Dyffryn Adda
- Undertake a survey of the waste tips to aid location and understanding of mining and processing
- Undertake a survey of the stratigraphy/petrography of the waste tips
- Undertake a survey of drainage patterns on the mountain
- Conservation of Mona Mine Yard (35,522) and of Parys Mine Yard footings (35,417)
- Identify and interpret surface sites of potential prehistoric mining (mostly under spoil?)
- Promote research potential in Environmental Science and in Industrial History
- Develop research and share policies with the major sites in Sweden (Kopparberg), Spain (Rio Tinto), Ireland (Avoca), etc.

7.5 Recommendations for scheduling enhancement

The following scheduled areas lie on or immediately adjacent to Parys Mountain:

An 111a	Windmill
An 111b	Pearl Engine House
An 111c	Mona Mine Precipitation pits
An 111d	Great Opencast
An 135a	Dyffryn Adda Adit portal
An 135b	Dyffryn Adda Leat and holding pond
An 135c	Dyffryn Adda copper furnace
An 135d	Dyffryn Adda Precipitation pits
An 136	Mona Mine kilns and sublimation chambers

The current scheduling provides protection for only a proportion of the sites identified as of national

significance. As has been made clear in the sections above, it is the interrelationship of sites, linked by drainage and transport, and the survival of the overall landscape, including the waste tips, which gives the site its particular significance. It is therefore recommended that the scheduled area be increased to include both a number of significant features currently not protected and the relationship between features. A suggested boundary is shown on figure 1.

Individual features identified as nationally significant which would be given statutory protection by this process would include:

35,522 Mona Mine Yard
35,215 An area of calcining kilns and flues belonging to the Parys Mine
35,308 Cairns shaft associated with the windmill and site of flat rods
35,245 Area of precipitation pits to north of Great Opencast
35,524 Dyffryn Goch precipitation system – the northern section of which contains small tanks considered to be an early system.
29,876Henwaith precipitation system and furnace (35,512). Though much of the Henwaith system has been altered during de-contamination works, there remains an early system (buried beneath heather) to the west, and the furnace building to the east.
35,289 Prehistoric site at Oxen Quarry
35,280 Charlotte Yard
35,463 Calciner building
30,404 Smelter
35,339 Site of horse whim and shaft
35,202 Mona footway with exposed stratigraphy and drains

7.6 Recommendations for interpretation

The interpretation has been considerably enhanced by AIHT over the last two years, and now includes a new centre in Porth Amlwch, interpretation boards located in the windmill on the mountain, a trail leaflet, and an iphone trail.

Future potential for enhanced interpretation could include:

- Supplement the iphone trail with android capability
- A choice of trail leaflets, to include a more detailed leaflet at higher cost

Interpretation boards in the interior of the windmill

8. SOURCES OF INFORMATION

8.1 Maps and Plans

Bangor University

Bangor MSS
31584: plan of Parys Mine by Henry Dennis of Rhiwabon, 1859
31590: plan of opencast and underground workings, 1892
31592: plan of Dyffryn Adda precipitation pits and furnace, nd.
31598-601: four copies of plan of opencast and underground workings, n.d.
31602: plan of Parys mine 1815 (copy of original (NMR C8236) made by E. Cockshutt 1966)
31603: plan of Mona mine, 1786 (copy of original (NMR C8235)made by E. Cockshutt 1966)
31604: 6”/1 mile ordnance survey map of Mynydd Parys, n.d.
Llwydiarth Esgob MSS
Fs 639/640/641
M/C
3/158

British Library
Cartographic Items Maps 6135.(1.) Lithographic Print of the Parys Mountain, shewing the position of the Anglesey Copper Mines, J. Briggs, 1824

Llangefni Record Office
WCD/118/1
WCD/118/3
WCD/118/4
WCD/118/7
WCD/118/9
WCD/118/14
WCD/118/15
WCD/118/16
WCD/118/19
WCD/119/1
25” Ordnance Survey map (III 15 Anglesey, 1887, 1900).

Hawarden Record Office
Deposit D/KK/534 (Keen and Kelly MSS) - map dated 1764.

National Monuments Record, Aberystwyth
C8235 Survey of Cerrig y Bleiddiau Mountain – map dated 1786
C8236 Map of Parys Mine, H. Hughes, 1815

National Library of Wales
Ms Maps 92 Plans and surveys of Land in the Counties of Carnarvon and Anglesey North Wales belonging to the Rev’d Mr Edwd Hughes By Jn Corris 1792. Page 41 Map and Schedule.

British Geological Survey, Llanfarian, Aberystwyth
D.O. December 1959, PP299/Do, III (Ms plan under varnish, J. Taylor and Sons).

Birmingham Reference Library
Boulton and Watt collection 6/6/85

West Glamorgan Record Office
D/D NAI M 10/1-6, D/D NAI/M 246/1-3 (plans of parts of 18” steam engine)

Public Record Office, Chancery Lane
SP 46/36 MPF 11 - map of Traeth Dulas and Amlwch, late sixteenth century

8.2 Paintings

British Museum

John Warwick Smith
The Copper Works on the Parys Mountain, Anglesey, 1792, water colour and gum.

Courtauld Institute of Art, London

Julius Caesar Ibbotson
Copper Mine in Anglesey, 1792, Oil.

National Library of Wales

Julius Caesar Ibbetson:
Paris Mine: aquatint after watercolour, shows the opencast with windlasses and whimseys, 1795; (PZ 3209 A1/1-A115).
Paris Mine, c. 1790 (PZ06467), Aquatint. J Bluck fecit.

Edward Pugh: Paris mines in 1800, aquatint (PA 4393, A1/1-A116). I. Havell sculpt.
-- Paris mines in 1804, aquatint (PA 4396 A1/1-A114).

John “Warwick” Smith:
One of the copper mines on the Paris Mountain belonging to the Mona Company, Angesea (PD092588)
General appearance of the copper mies on the Paris Mountain as they appeared in the year 1785, Anglesea, (PD09259)
Interior of one of the Copper Mines on the Paris Mountain (PD09260)
One of the copper mines belonging to the Paris Mountain Company, Anglesea (PD09261)

Warrington Smyth

The great opencast, c. 1850, water-colour.

National Museum of Wales
Julius Caesar Ibbetson:

Plas Newydd: collection of the Most Hon. the Marquis of Anglesey
William Havell
The opencast, 1803-4, oil.

8.3 Unpublished texts

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