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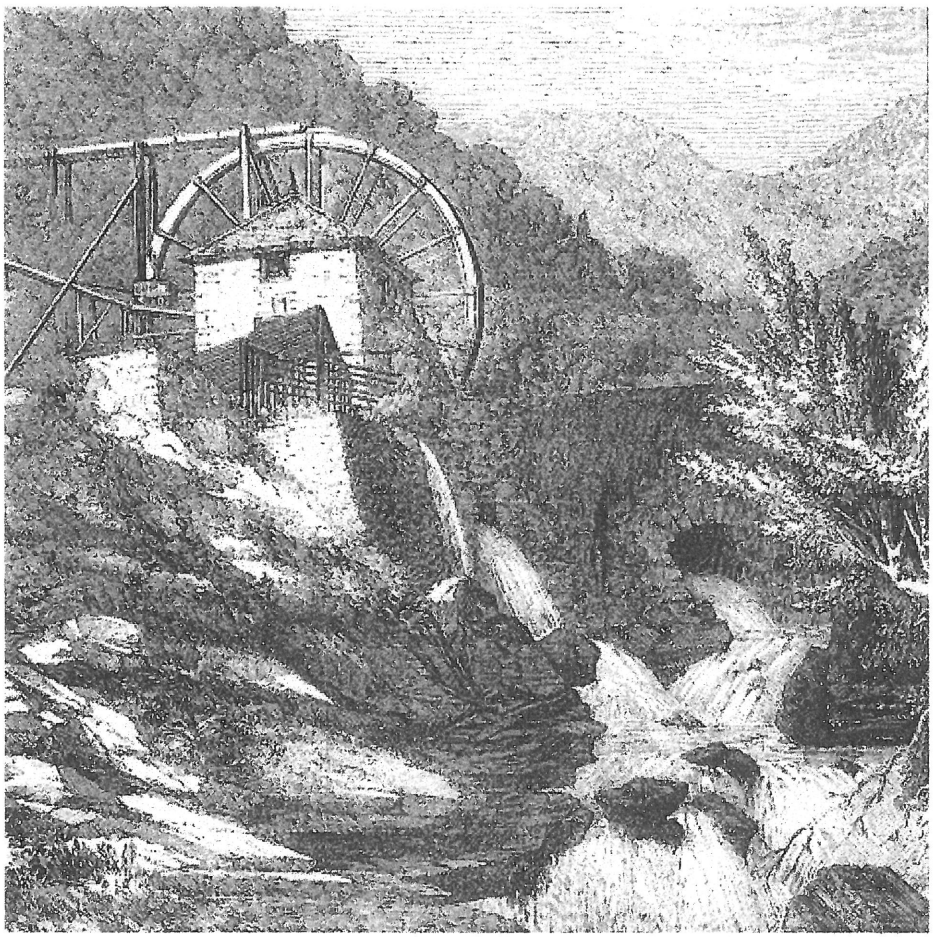
GWYNEDD METAL MINES SURVEY



Report No. 291

Ymddiriedolaeth Archaeolegol Gwynedd

Gwynedd Archaeological Trust

GWYNEDD METAL MINES SURVEY (G1468)

prepared for Cadw: Welsh Historic Monuments

by Dr. D. R. Gwyn

Gwynedd Archaeological Trust Report No. 291

"Am y wlad a addewid gynt i feibion Israel, diwedid am dani mai gwlad oedd 'yr hon y mae ei cheryg yn haiarn, ac o'i mynyddoedd y cloddi bres.' Gwlad felly ydyw Cymru."

Anhysb., *Y Faner* 26 Awst 1863

"Welsh mines, and the profits Marius had out of them ....."

Ezra Pound, *The Cantos*

Abbreviations

The following abbreviations are standard:

CDH: Caernarfon and Denbigh Herald
CRO: Caernarfon Record Office, Victoria Dock, Caernarfon, Gwynedd
DRO: Dolgellau Record Office, Cae Penarlag, Dolgellau, Gwynedd
GD/IG: Gwynedd Diwydiannol/Industrial Gwynedd
IAR: Industrial Archaeology Review
JMHRS: Journal of the Merionethshire Historical and Record Society
MbP: Mining before Powder (published as a Peak District Mines Historical Society Bulletin vol. 12 no. 3, and as a Historical Metallurgy Society special publication, Summer 1994)
MGF: Mines of the Gwydyr Forest
MJ: Mining Journal
NLW: National Library of Wales
NWC: North Wales Chronicle
TAAS: Transactions of the Anglesey Antiquarian Society
TCHS: Transactions of the Caernarvonshire Historical Society
UWB: University of Wales, Bangor

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SUMMARY

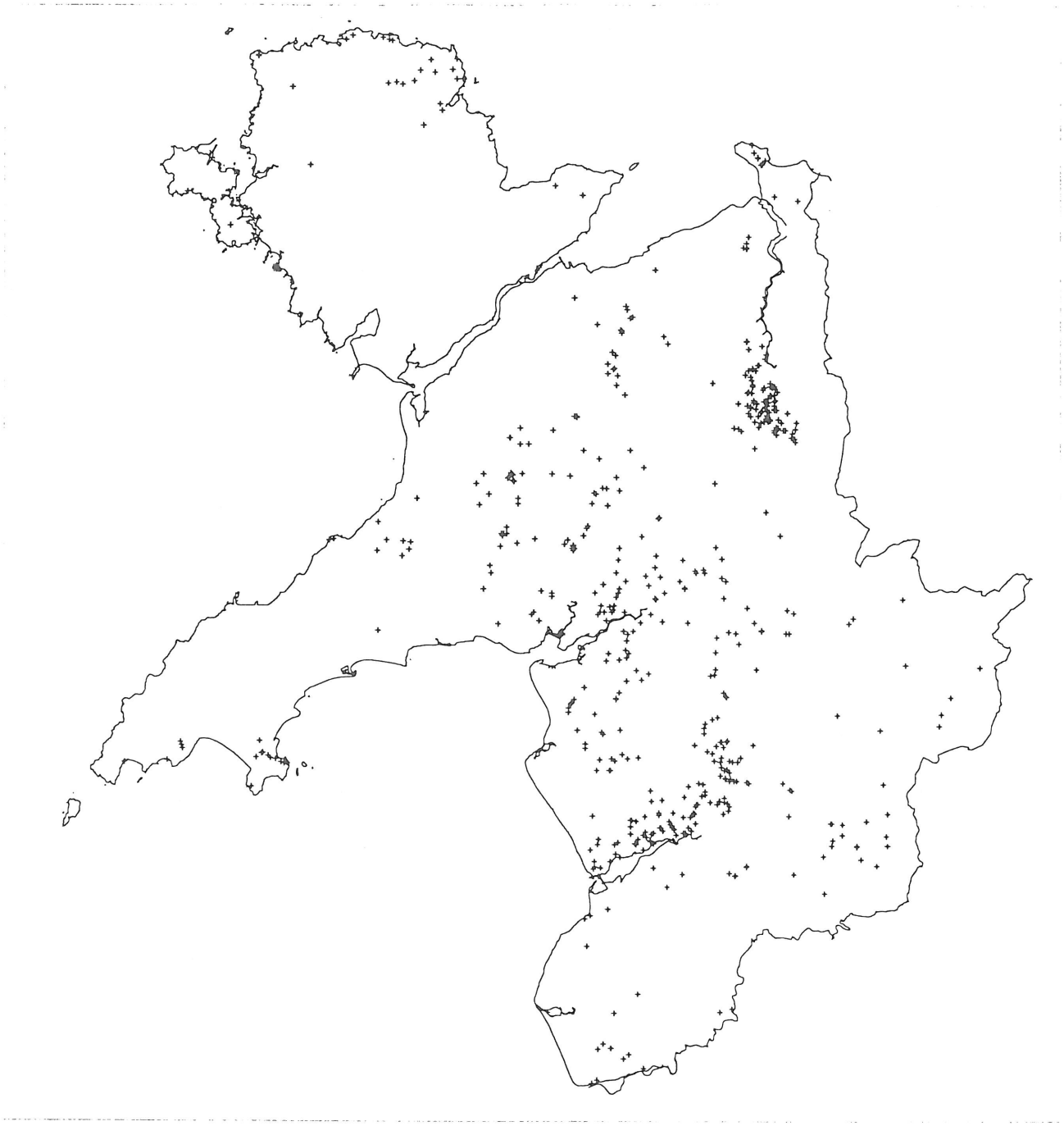
The present project has identified a total of 587 ferrous and non-ferrous mining sites in Gwynedd. All were allocated to one of five categories of archaeological significance (as defined in the report), with ***category A*** *representing sites of outstanding importance. A total of* ***14*** *sites were allocated to* ***category A****, of which all had been visited, a total of* ***24*** *had been allocated to* ***category B****, of which all had been visited, and* ***38*** *to* ***category C****, of which all had been visited. A total of* ***47*** *had been allocated to* ***category D****, of which* ***38*** *had been visited, and* ***466*** *to* ***category E****, of which* ***22*** *had been visited. A total of* ***136*** *sites was therefore visited in the course of the project.*

The project identified a total of ***11*** *sites for which there was archaeological or circumstantial evidence for having been worked in* ***Prehistory****, all of which were visited,* ***1*** *site for which there was circumstantial evidence for operations having begun in the* ***Roman*** *period, and* ***3*** *for which there was circumstantial evidence for operations having begun in the* ***Medieval*** *period, all of which were visited. The remaining sites were ascribed to the* ***post-Medieval*** *period, and* ***120*** *were visited.*

The project confirmed the significance of the area as a mining field in Prehistory, with very substantial surface and underground workings on the Great Orme and at Mynydd Parys. It has set out the evidence for Roman and Medieval mining in the area.

The total archaeological resource for the county of Gwynedd within the post-Medieval period was found to contain one of the most productive lead-mining fields in the United Kingdom, at Gwydir in Dyffryn Conwy, and a considerable number of copper-mines, including Mynydd Parys, the most productive copper mine in the world in the eighteenth century. In addition, the area was found to have entirely dominated the production of gold within the United Kingdom, and also of manganese, an essential component in the the evolution of modern steel-based technology. Important technological developments were found to have been originated and first commercially employed in Gwynedd, in particular the use of flotation.

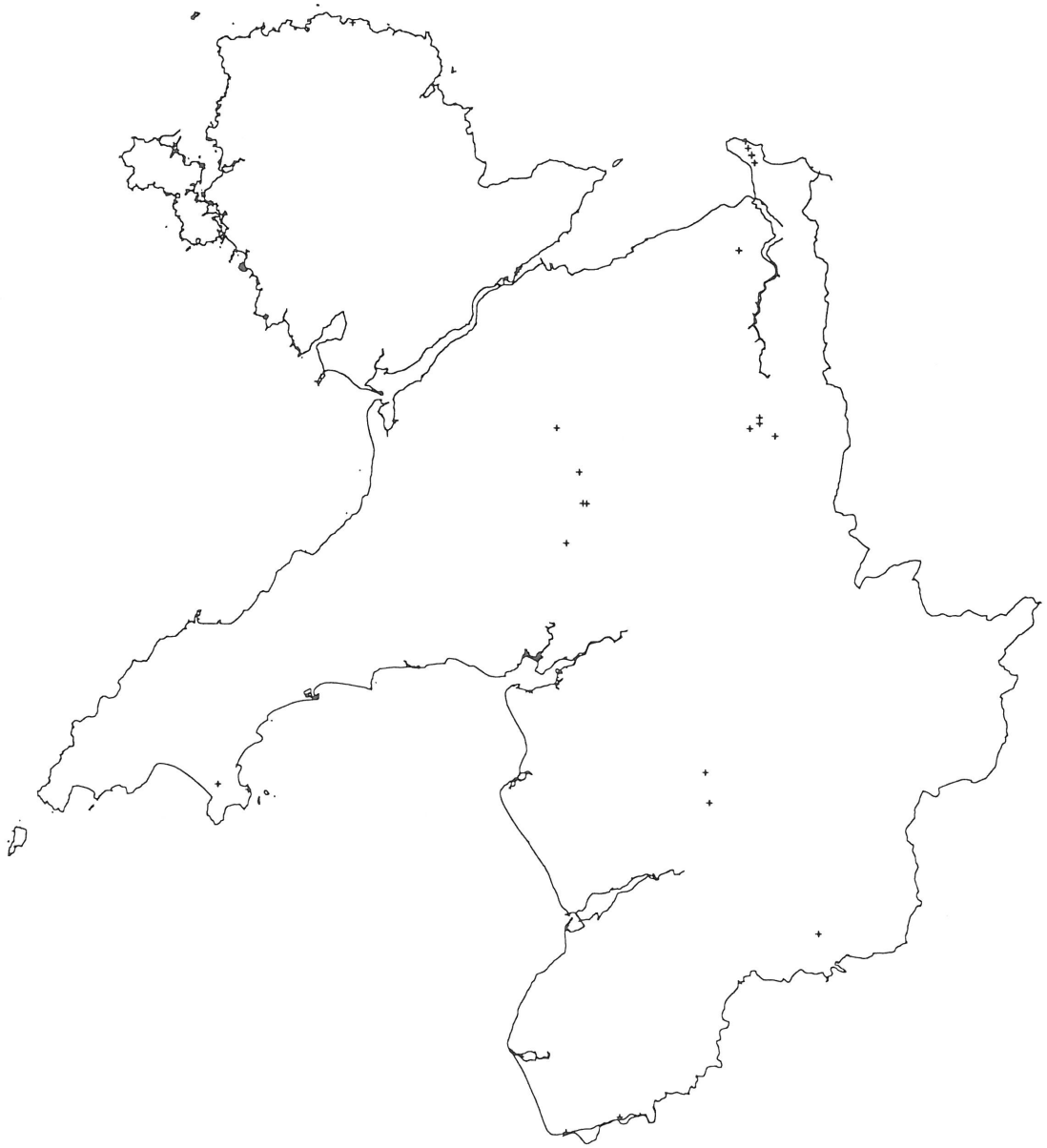
Its archaeology has been shown to be a resource of international significance.



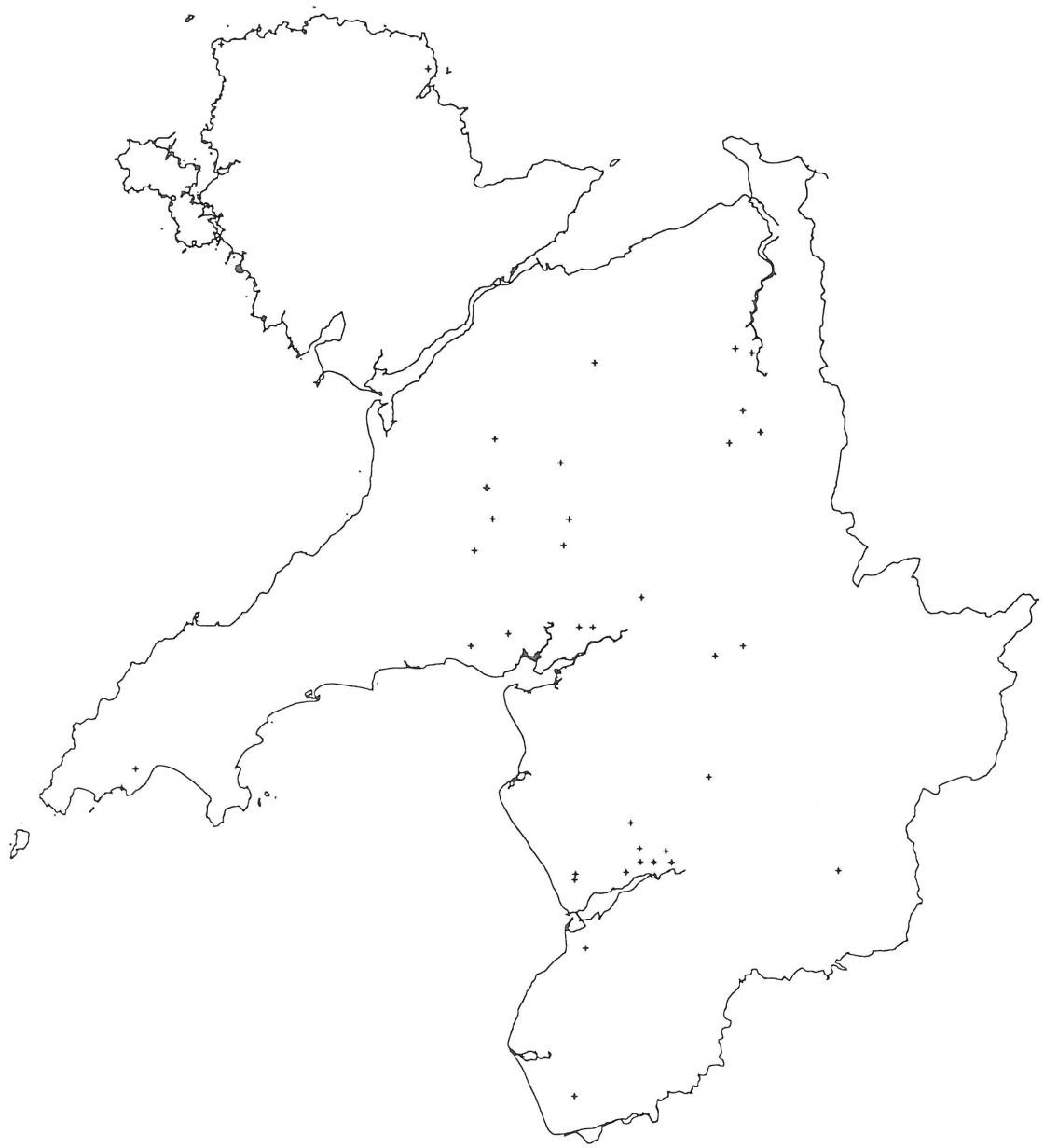
1. All mine sites noted in the present survey

2. Sites visited in the course of the present survey

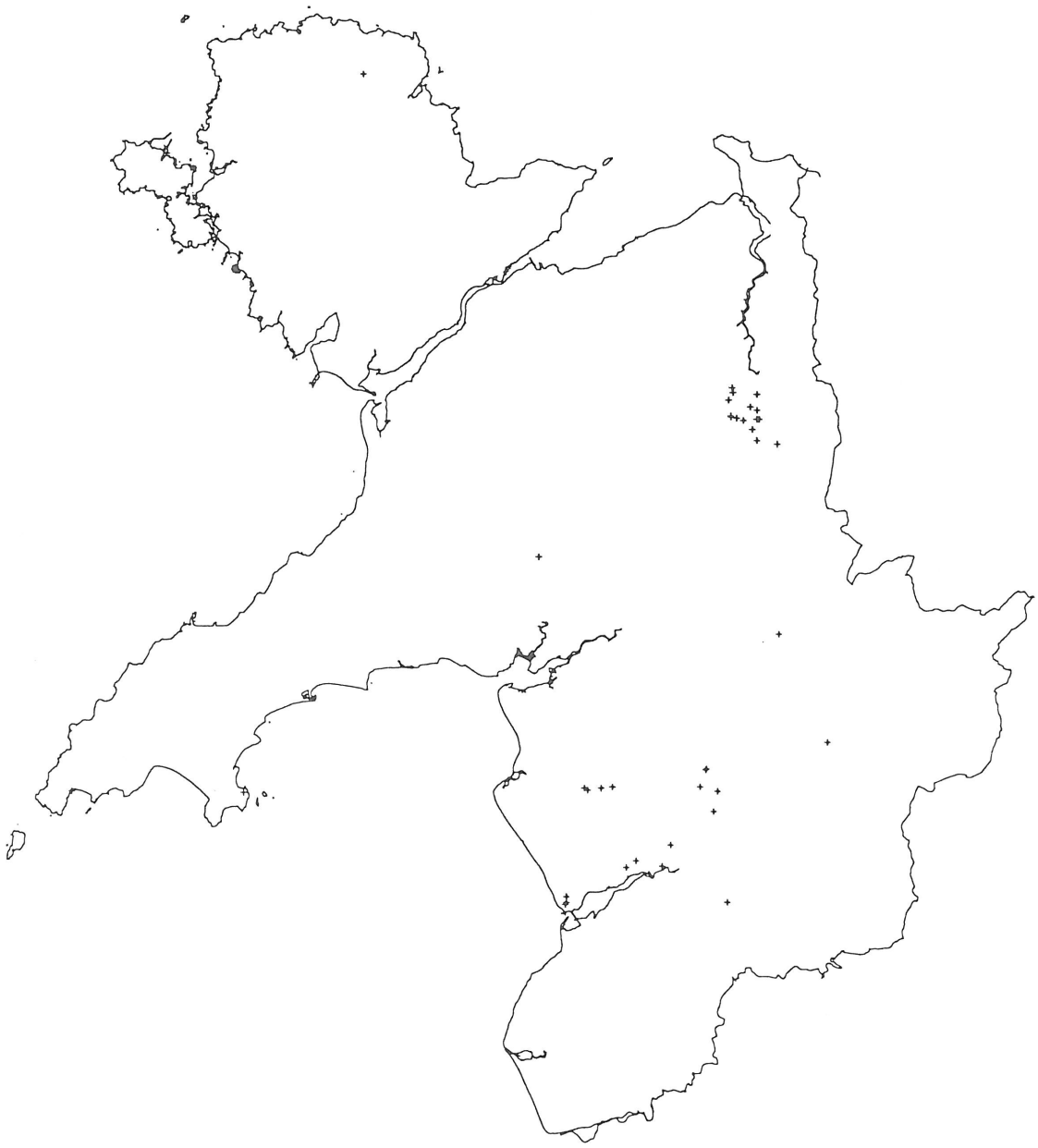
3. Sites graded A visited in the course of the present study



4. Sites graded B visited in the course of the present survey



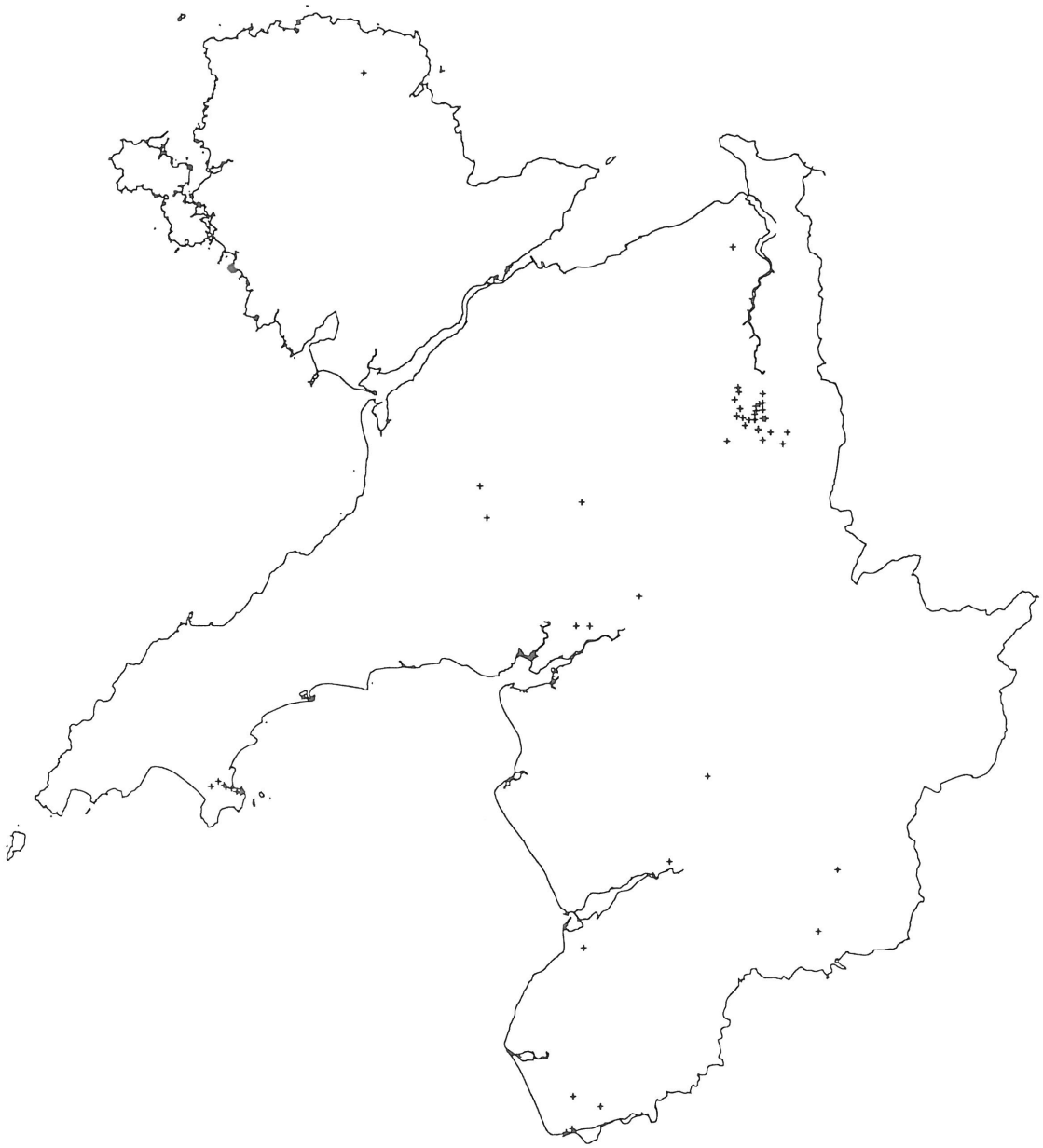
5. Sites graded C visited in the course of the survey



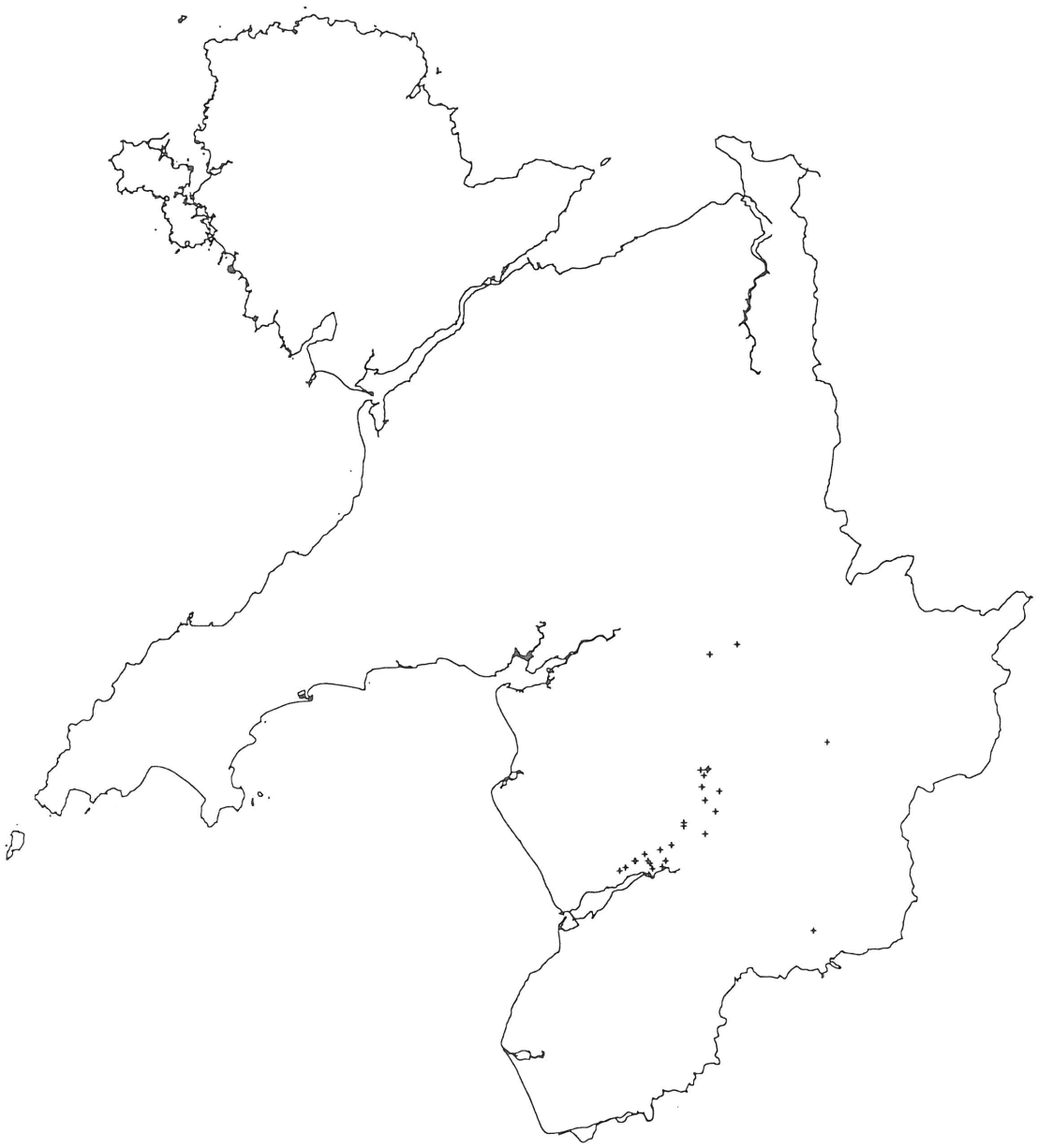
6. Sites graded D visited in the course of the present survey

7. Sites graded E visited in the course of the present survey

8. Copper mine sites visited in the course of the present survey



9. Lead mine sites visited in the course of the survey



10. Gold mine sites visited in the course of the present survey

11. Other mine sites visited in the course of the present survey

1. INTRODUCTION

1.1 Background

This project has been funded by Cadw: Welsh Historic Monuments, with the intention of carrying out an archaeological assessment of the ferrous and non-ferrous metalliferous mines of Gwynedd (pre-1996 boundaries), excluding the mine sites on Mynydd Parys in Anglesey, which form the subject of a separate assessment. Mynydd Parys is, however, referred to at several points in the present document for comparative purposes.

These sites have long been known to represent an important part of the industrial archaeology of the area. Increasingly, evidence is coming to light of Bronze Age copper working, and circumstantial evidence of Roman working. The same lodes were very often extensively and systematically worked from the late eighteenth century to the mid twentieth. In terms of copper production, Mynydd Parys dominated Welsh output, producing in 1859 13,555 tons out of a Welsh total of 15,843[1] and the lead mines of Caernarfonshire by the end of the nineteenth century were almost as productive as those of Cardiganshire, previously the most important source of lead ore in Wales.[2]

1.2 Extent of the resource.

Previous research based on cartographic and archival sources has identified most of the metalliferous mine sites in Gwynedd (pre-1996 boundaries), an area largely co-terminous with the former counties of Anglesey, Caernarfonshire and Merioneth. It appears that lead has been mined at well over a hundred locations in the County of Merioneth, and at well over two hundred in the County of Caernarfonshire. Copper has been extracted at over sixty locations in Merionethshire and over a hundred in Caernarfonshire. These figures are not exact; some sites produced both lead and copper, or other metal, and sites with different names may prove to be one and the same as a result of further documentary research. The figures for Anglesey are smaller, although dominated by the enormous undertakings at Mynydd Parys. There were in addition gold, silver, antimony, zinc, sulphur, ironstone and manganese mines. It was clear that the number of sites ran into many hundreds, varying in size from Mynydd Parys to tiny trials.

Definition of what constitutes a site is a perennial difficulty, and is discussed in **3.6** below.

Whilst slate has been extracted at over four hundred locations throughout Gwynedd, study of the slate industry has been greatly facilitated by the production of Alun Richards' *Gazetteer* in 1991, which, though often weak in point of detail, does nevertheless include an attempt at an overall assessment of the archaeological resource. The work of Messrs Bennett and Vernon has greatly amplified knowledge of lead-mining in the Gwydir forest, and includes measured surveys, but other important mining areas like the Orme, Drws y Coed, Beddgelert-Nanmor, Figra, Gwynfynydd and Glasdir have so far not enjoyed this level of recording. The invaluable reference works of David Bick, George Hall and others record structures and machinery, but do not include measured surveys.[3]

1.3 Nature of the threat

The threat to the archaeology of metalliferous mining sites is various. Most are at risk from benign neglect, and many sites are under active threat from forestry, agriculture or public access. Mynydd Parys is a site particularly at risk, with fly-tipping a recurrent problem, and the modern mine itself on a care-and-maintenance basis. The archaeology of two gold mines sites is at risk from continued production; Gwynfynydd employs two men, and three men are at work at Llechfraith mine and at the Ty'n y Cornel adit of Clogau mine.

The surviving buildings at a considerable number of former metalliferous mines are at risk from collapse, a situation exacerbated by their proximity of many sites to footpaths and roads. In the Gwydir forest, though consolidation has taken place at a number of sites, the Klondyke mill building is deteriorating significantly. Elswhere, consolidation and clearance has been carried out by Snowdonia National Park volunteers at the Glasdir site, which is nevertheless being repossessed by vegetation.

Tourism has led to the opening of a number of sites, most notably Sygun, near Beddgelert, and the Great Orme mines, both of which are run by organisations fully aware of their responsibility to heritage. However, Gwynfynydd has found that tourism is less lucrative than mining and has reverted to being purely a mine as the tourist facilities are

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[1] *Hunt's Mineral Statistics, passim.*

[2] J Williams, *Crynhoad o Ystadegau Hanesyddol Cymru* (Aberystwyth, 1986).

[3] A Step 1 report was produced in March 1993 by David Cranstone of The Cranstone Consultancy on copper mining sites in England (including Cornwall) - see **9. Bibliography**.

run down.

2. AIMS

The aims of this study were:

2.1 To identify all the metalliferous mine sites of archaeological significance within Gwynedd (pre-March 1996 boundaries).
2.2. To identify the major archival holdings and bibliographic references (English- and Welsh-language) relating to these sites.
2.3 To assess the surviving archaeological resource at these sites.
2.4 To assess the threat to these sites.
2.5 To make management recommendations.
2.6 To produce a report embodying **2.1-2.5** above.

3. METHODS AND TECHNIQUES

This study followed a broadly similar approach as the 1994-5 Gwynedd Archaeological Trust *Gwynedd Slate Quarries: An Archaeological Survey* (Report 154), and to the metalliferous mining projects carried out by the other Welsh regional trusts.[4]

3.1. Desk top

Preparatory **desk-top** work identified:

i. The number (587 identified sites) and location of metalliferous mines in Gwynedd. To this end bibliographic and cartographic evidence was used, as well as information contained in the Trust's own SMR. The lists of sites drawn up by the National Museum of Wales, by the Snowdonia National Park and by interested individuals were also consulted.

ii. The likely scale of archaeological importance of all individual sites, each of which has been allotted to a category A to E, depending on scale and likely survival of archaeological features, derived from bibliographic and cartographic evidence, and after discussion with consultees (see **3.2** below).

Category A is defined as a site of considerable size in which a considerable number of features of archaeological importance survive, or which contains a small number of features of great significance and in good condition, or which contains archaeological evidence of extensive Prehistoric working.

Category B is defined as a site of more modest size but which contains a wide variety of features of archaeological significance, or which contains archaeological evidence of Prehistoric working.

Category C is defined as a small site which nevertheless contains a variety of features of archaeological significance, or which contains archaeological evidence for pre-Modern working.

Category D is defined as a small site in which there may have been some limited degree of mechanisation but which does not contain many features of archaeological significance, or in which there is circumstantial evidence for pre-Modern working.

Category E is defined as an unsuccessful trial or short-lived working from the Modern period that never achieved any degree of mechanisation, or in which the archaeology has been substantially destroyed.

A bibliography of each site in categories A to D was entered on the database and for sites in category E where bibliographic evidence was available.

3.2 Consultation

A number of relevant historians, archaeologists and other specialists in the field of metalliferous mining were

[4] Clwyd-Powys Archaeological Trust, *Clwyd Metal Mines Survey 1993*, *Powys Metal Mines Survey 1993*, Dyfed Archaeological Trust, *Dyfed Metal Mines Survey*

consulted, as have a number of locally-based enthusiasts. These include Nigel Bannerman, John Bennett, David Bick, Peter Crew, Peredur Hughes, Dr David Jenkins, Dr Gwynfor Pierce Jones, Dr Michael Lewis, Steffan ab Owain, Tom Parry, Simon Timberlake, Robert Vernon, David Wagstaffe, Jeremy Wilkinson and Chris Williams

3.3 Field work

A total of 136 sites was visited, and an archaeological assessment carried out on each one using the standard field work form. All sites initially placed into categories A, B and C were visited, as many as possible from category D and a representative sample from category E, with emphasis on those smaller sites which were near to sites in the first four categories. As a result a small number of sites were upgraded and downgraded to different categories. Field work involved the assessment of all visible above-ground features of the mines, but no attempt was made to explore underground. The one exception to this was the Ty Gwyn mine at Llandudno where a tramming level was known to have been preserved in remarkably good condition, and to be accessible from the surface. Where underground features are known to survive, on the report of cavers and amateur enthusiasts, they are noted in **Appendix 2.** (see **3.4** below).

As a result of field work, the categories of a number of sites were altered.

It must be emphasised that sites which have not been visited may prove to be archaeologically significant. An example of a site which on bibliographic and cartograpical evidence alone would be graded D is Pant y Gaseg, whose value is greatly increased by the possibility of Prehistoric working on this site implied by the hammer-stones and piled spoil. It is recognized that the study of pre-Modern metal mining is still in its infancy, to such an extent that the word "early" is deliberately used by some authorities to cover all periods from the Bronze Age to the eighteenth century,[5] and even a small-scale nineteenth century scratching, perhaps carried out by unemployed miners, can appear little different from a mine that is three thousand years older.

3.4 Report

Information derived from field work and from desk-top study was entered onto a data-base, which accompanies the present report as the gazetteer in **Appendix 2.**

3.5 Existing statutory protection

Ten areas which constitute parts of metalliferous mining sites are scheduled as Ancient Monuments (including Mynydd Parys):

Klondyke mill	C159	Trust PRN: 4639
Drws y Coed Mine mill complex	C162	Trust PRN: 20535
Cwm Ciprwth Mine (as Gilfach Mine)	C170	Trust PRN: 21578
Cwm Erch Mine	C193	Trust PRN: 3396
Great Orme prehistoric mine (underground)	C216	Trust PRN: 1694
Cefn Coch and Berthlwyd gold-mining complex	M119	Trust PRN: 4299
Mynydd Parys Mine windmill:	A111A	Trust PRN: 3497
Mynydd Parys Mine Pearl engine house:	A111B	Trust PRN: 3499
Mynydd Parys Mine Hillside precipitation pits:	A111C	Trust PRN: 3498
Mynydd Parys Mine Great Opencast:	A111D	Trust PRN: 3496

3.6 Historic landscapes

Gwynedd's metalliferous mines have been identified as components of a number of historic landscapes of Wales, as set out in the recent Cadw/Countryside Council for Wales/International Council on Monuments and Sites *Register of Landscapes of Outstanding Historic Interest in Wales*. Evidence of metalliferous mining is cited in 19 (Amlwch and Parys Mountain), 23 (Creuddyn and Conwy), 27 (Dyffryn Nantlle), 31 (Bro Dolgellau) and 32 (Mawddach). In addition, the intensive exploitation of lead in the Gwydir forest throughout the Modern period has created a distinctive industrial landscape in the area between Trefriw and Betws y Coed, where a number of features have been conserved, though spoil tips have been destroyed.

3.7 Definition and name of sites, spelling

Individual mine sites have often gone through many different names - typically an eighteenth or early nineteenth

[5] David Cranstone, "Early Surface Features of Metal Mining: Towards a Typology", *MbP* p. 144.

century working might be identified topographically or occasionally by the name of the contracted miner, then be incorporated in part of a sett granted to a limited company quoted on the stock exchange or to a cost book company. The less reputable of these would concoct a name that hinted at great things ("New California" for example, or anything with the word "Consols" in the title) or one that was so vague as to prevent shareholders or correspondents to the *Mining Journal* even finding out where the operations lay - such as the Nelle Gwynne Mine in Llanfihangel y Pennant. The complexities of these setts and leases is made clear by John Bennett and Robert Vernon in their series of books on the Gwydir forest, where between 1853 and 1889 no less than fourteen companies, constituted in various ways, took leases on the area which became the Parc Mine. As much as possible, therefore, the present report has considered as a single and complete site the areas comprehended in the later leases, and has distinguished wherever possible in **Appendix 2** the different periods of working comprehended within them. It is, however, only in the case of the Gwydir mining area that existing research has identified precise lease-boundaries, and for most sites in the present report the limit has been taken to be the field walls or other boundaries which enclose a concentrated area of mining. Occasionally small adits some distance away, which have the appearance of unrelated trials, have proved to be a drainage adit, such as Penmorfa at Llandudno, in which case they have been mentioned in the gazetteer. It must therefore be emphasised that the areas indicated on the maps included as part of the gazetteer in **Appendix 2** constitute the limits of the study area, rather than known mining boundaries.

As much as possible, local mine names have been preferred in the present report - therefore the site sometimes known as Prince Edward Mine appears here as Bwlch y Llu, Princess Marina Mine as Bedd y Coedwr. Variants are noted in the site entries in **Appendix 2.** However, the mine on the southern slopes of Snowdon has most commonly been referred to throughout its recent history as Britannia, which has therefore been used in the present study.

Throughout this document the form Gwydir has been used in preference to Gwydyr.

4. RESULTS OF THE DESK-TOP STUDY

4.1 Documentary resource.

Metalliferous mining in Gwynedd in the Early Modern and Modern periods has historically been characterised by limited success, frequent bankruptcy and liquidation, and on occasions by outright fraud. A few mines were consistently successful for long periods of time, but, apart from the recent revivals at Mynydd Parys, Llechfraith and Gwynfynydd, closures came early. Deep mining ceased at Mynydd Parys at the end of the nineteenth century (though a shaft has been sunk more recently), the gold workings on the Mawddach had all but come to an end by the 1930s and though Parc lead mine continued in operation until 1963, all of the other Gwydir workings were by then long moribund. This is reflected in the nature of the documentary resource.

The short-term nature of metalliferous mining has meant that rarely does a company's internal archive survive. An exception is the Mona mine collection on Mynydd Parys, preserved in the UWB archives, which is very far from comprehensive, but does enable a partial reconstruction of the mine's fortunes. The Fanning Evans papers, recently deposited there but not yet catalogued, will, it is hoped, shed light on the last period of operations on Mynydd Parys, until the precipitation system was abandoned in 1958.

Estate papers constitute a valuable source-type. The careful scrutiny exercised by the Vaynol estate over their tenants at Drws y Coed, Llanberis and Clogwyn Goch mines has meant that very detailed accounts survive for their operations, often on a month-by-month basis. These sites therefore have a very full archive, which was consulted in the course of the present study. The majority of Gwydir estate papers is preserved at the Lincolnshire Record Office, and were made available to Robert Vernon and John Bennett in their researches. The papers of the Mostyn and Baron Hill estates at UWB[6] and of the Diocese of Bangor, the Wigfair collection, Plas yn Cefn and the Welsh Church Commission at NLW[7] are particularly useful in reconstructing the evolution of the Llandudno mines, where comparatively few surfaces features survive.

The papers of smaller estates have tended not to survive. Little remains of the archives of the Bryncir estate, which owned many of the Cwm Pennant mines, nor of the Ormesby-Gore family, which owned the neighbouring lands in the region of Llanfrothen and Penrhyndeudraeth. Occasionally, scattered papers survive in collections such as those of the lawyers Breese Jones and Casson in the CRO, or Porth yr Aur in NLW.

The Crown Estates preserve not only the lease documents, including maps, for royal lands but also other

[6] UWB Mostyn MSS, Baron Hill MSS

[7] NLW Bangor Diocesan Records B/DL, B/EP, Wigfair MSS (and NLW MSS 12506013), Plas yn Cefn MSS, Welsh Church Commission (ECE/AD/B138-141)

documentation relating to their tenants. These are likely to form an archive of very great importance for the study of many of the Merionethshire gold mines in particular, and are currently held at the Public Record Office in Chancery Lane. These were not consulted in the course of the present study; they do not appear to have been consulted in the preparation of Messrs Hall and Morrison's histories of the gold mines.

The Public Record Office also holds the files of dissolved limited companies in the Board of Trade archive at the Kew offices, as BT31 and BT41. An abstract of those that relate to Gwynedd has been prepared by Jeremy Wilkinson and a copy has been deposited in each of the county record offices at Caernarfon, Dolgellau and Llangefni.

Another useful official source is the Home Office published *List of Mines and Quarries,* which includes figures for the number of persons at work and output figures for all workings from 1895-6 - too late for most Gwynedd mines. Mr Wilkinson has presented photocopies of all of these to the County Record Offices.

Abandoned Mine Plans, formerly lodged with the Health and Safety Executive at Bootle, were transferred to the County Record Offices in the late 1980s. These form a valuable source but tend only to include mines working towards the end of the nineteenth century or later, and are in any case not necessarily abandonment plans, but only an available map of the workings. Ordnance Survey maps were in some cases useful, though many mines had closed before the first 25" surveys were produced in 1886-8. Nevertheless, they generally mark the positions of adits and of features which might already have been out of use but which have since degraded completely. The comparatively small size of most mines in Gwynedd meant that few appear on the 1" survey of 1839 to 1841, though this forms a useful source for some of the larger mines, such as the Great Orme.

As well as the official or semi-official records, very many other forms of archive and bibliographic evidence survive. By far the most important is the *Mining Journal*, of which copies exist at the NLW, HRO and Manchester Central Reference Library. This was the first place where an aspiring financier would announce a new venture and solicit potential investors to buy shares; it was also the place where, a few months later, disgruntled shareholders would air their complaints, and commercial rivals would publish a character assassination. Its columns make fascinating reading, not only for the wealth of information they contain but also for the very different corporate ethics of the nineteenth century. However, the task of cataloguing these entries is enormous, and can not be attempted within the scope of a study such as this.

Of other technical publications, the *Annales Des Mines* is known to have published articles on metalliferous mining in Britain. This journal first appeared in the French revolution, and has been published ever since; the opportunity was taken recently to consult the run held by the University Library, Cambridge, and it is clear that a detailed examination might yield interesting results.

As well as Frenchmen and Germans, other visitors made their way to Gwynedd, in particular to Mynydd Parys but also sometimes to other mines. Edmund Hyde-Hall and the Rev. Mr Bingley both published their impressions of some of the mine-workings, the one out of a statistical impulse, the other in order to do justice to his feelings of sublime terror.[8]

This élite interest in Gwynedd and in its economic resources and scenery is reflected in a number of paintings which record mine-workings. John "Warwick" Smith's painting of the lake and the ore-chutes at Llanberis, records a now-vanished aspect of this site, and is on view in the Lady Lever Art Gallery, Port Sunlight. A sketch by Edward Blore shows the Llandudno Old Mine engine-house and Vivian's shaft,[9] and Don Smith's history of the Great Orme mines shows water-colours by Felicia Simpson, now in private possession, of the engine houses and the flat-rod system.[10] H.E. Tidmarsh's water-colours of the Gwydir mines are preserved in the NLW.

Engravings and other drawn visual material can be of importance in interpreting particular sites, such as the woodcut of Figre gold mine which appeared in *The Illustrated London News* in 1862.[11] In this instance the photographs from which they were prepared appear to have survived, and must rank as among the earliest photographs taken in Merionethshire. These are preserved in the Dolgellau Record Office.[12] Some particularly fine photographs of the Llanberis copper mine possibly by Francis Frith and Vale of Conway lead mine, taken by John Thomas of the

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[8] E. Hyde Hall: *A Description of Caernarvonshire* (Caernarfon, 1952, from UWB Bangor MS 908), W. Bingley: *A Tour Around North Wales Performed in the Year 1798* (London, 1804) vol. I, pp. 231-3.

[9] BL Add. MS 42037, f. 39

[10] D. Smith, *The Great Orme Copper Mines* (Rhuddlan 1988) front and back covers.

[11] *Illustrated London News* 4 January 1862, p. 13.

[12] DRO Z/DC 176-181.

Cambrian Gallery, Liverpool, probably *c.* 1874, have recently been published.[13]

The growth of commercial photography in the last years of the nineteenth century meant that a number of mine views were developed as postcards, such as the well-known group outside the adit of Clogau mine.[14] The County Record Offices hold a number of collections of photographs of mine sites, mostly taken when they were out of use but sometimes before utter dereliction had set in, though Geraint Madoc-Jones began taking photographs when at least Bwlch y Llu mine was still working.[15] Parc mine in the Gwydir forest remained in use until 1963, and a number of photographs of its last phase of working have been published.[16]

For the most part, unlike the slate industry of Gwynedd, the metal mines were not sufficiently large employers nor sufficiently sure of their future to engender the strong sense of community loyalty which remains a strong feature of slate-quarry towns and villages like Bethesda, Blaenau Ffestiniog and Tal y Sarn, and perhaps for this reason copper, lead and gold mines were rarely celebrated in eisteddfod essays and other Welsh-language sources. Tellingly, an exception is Owen Griffith's *Mynydd Parys*, printed at Caernarfon in 1897, but smaller workings are not so commemorated. They are mentioned sometimes in parish histories as part of the overall picture, and these references, though brief, can be useful - for example Alltud Eifion's *Y Gestiana sef Hanes Tre'r Gest*, published at Tremadog in 1892 which describes amongst others the Bron y Gadair mine near Pentrefelin, without which very little would be known about this once-important site.

Otherwise, local newspapers, sale catalogues and other chance documentation provides the most useful sources for many of these sites, but the task of collation is enormous. As an example, all the known documentation for one small site which has been thoroughly researched, Bryn y Felin in Aberglaslyn, is included in the gazetteer in **Appendix 2**.

What may be termed the modern phase of interest in Welsh mines begins after the end of the Second World War. David Bick began his researches and field-work in the 1940s, and a number of other enthusiasts date their interest in the Gwydir mines from schooldays at Rydal in the same period or some time after - Robert Clough and John Bennett are both Old Rydalians. F.J. North's *Mining For Metals in Wales*[17] is still of interest, and the published work of his successor as Director of the Department of Industrt at the National Museum of Wales, D. Morgan Rees, did much to stimulate interest in industrial archaeology in Wales in the 1960s and 1970s. The publication of books by David Bick, John Bennett, Robert Vernon, Chris Williams and others since then has done much to advance the cause. These are mainly site- or area-based; one recent Welsh language publication is Steffan ab Owain's *Geirfa'r Mwynwyr* ("Miners' Vocabulary"), which is a compendium of terms used by metalliferous miners in Wales, but with particular emphasis on Gwynedd. This includes much valuable incidental information, such as field names connected with mining (see **4.2** below).

Published work until the 1980s concentrated almost entirely on mining in Modern or Early Modern times, and it was not until exploration on the Great Orme in the late 1970s that conclusive evidence came to light for Prehistoric mining. Since 1990 in particular published works and theses by Andrew Lewis, Peter Crew, Simon Timberlake, David Jenkins, Andrew Dutton, Susan Jones and others have highlighted the extent of Bronze Age mining in particular. It is now clear that not only was the Great Orme a major centre of copper production in the ancient world, but that Mynydd Parys and a number of smaller locations were actively exploited in this period. These publications have taken place against a background of increased interest in early mining by archaeologists and other specialists world-wide, which has led to the identification of Prehistoric workings in a great number of locations.

4.2 Place-name evidence

One other form of evidence deserves mention. Place names such as Pont Stamps ("stamp bridge") and Cae Fflowrin ("smelting field", literally "flowering [of sulphur] field") are evidence of past activity, as are more generalised names such as Bwlch y Plwm ("mountain pass of the lead").[18]

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[13] In *Archive* vol. 4, pp. 28-29, and in J. Bennett and R. Vernon *MGF* 2 (Cuddington, 1990) p. 55.
[14] Published as the front cover illustration to Roger Burt, *A Bibliography of British Metal Mining* (Exeter, 1988).
[15] DRO ZM/1435.
[16] John Bennett, Rob Vernon, *MGF* 3 (Cuddington, 1991) *passim.*
[17] F.J. North, *Mining for Metals in Wales* (Cardiff, 1962)
[18] Steffan ab Owain, *Geirfa'r Mwynwyr* (Capel Garmon, 1988) *passim.*

5. HISTORICAL AND ARCHAEOLOGICAL SUMMARY

5.1 Historical Summary

5.1.1 Prehistoric mining

Evidence for early mining in Gwynedd was first recognised in 1831 and 1849 with the discovery of stone and bone tools on the Great Orme mines,[19] and by the work of Oliver Davies between the wars, though he ascribed a Roman date to workings now believed to be much older.[20] Evidence for Prehistoric mining has also emerged at Mynydd Parys and Pant y Gaseg on Anglesey, at Corbet Dovey mine and Pant Eidal in southern Gwynedd, and recorded at Trecastell in Aberconwy.[21] The possible calibrated age-ranges for sample materials from Parys Mountain and the Great Orme, are 2040 BC to 1750 BC and 1410 BC to 1070 BC respectively.[22]

On present evidence it appears that the Great Orme mines were the most extensively exploited, making use of horizontal galleries up to 50m in length and at vertical depths of approximately 30m in which firesetting had been used to extend the workings.[23] However, Mynydd Parys was also exploited on a significant scale, both above-ground and underground,[24] and it is therefore clear that Gwynedd was a major supplier of copper ore in Prehistory, along with Cwmystwyth and a number of other sites in the former Dyfed, County Cork, Alderley Edge in Cheshire, and a number of other sites in England and the Isle of Man.

5.1.2 Roman mining

Conclusive evidence of Roman mining in North-west Wales is lacking; however, the discovery in Anglesey of more than half a dozen copper cakes (plano-convex ingots), some with recognisable Roman inscriptions, argues that Mynydd Parys was exploited in this period. Other cakes discovered on the mainland of Gwynedd may have come from Anglesey, or more locally - possibly the Great Orme.[25] A Roman date has recently been sugested for Caemawr in Aberconwy.[26]

5.1.3 Medieval mining

Archaeological evidence for Medieval mining is inconclusive. At Drws y Coed a Medieval date has been suggested for two coffin-section adits on the south side of the pass[27] but this remains unsupported by any firm evidence. No documentary sources confirm mineral extraction in this period though the charter of Cymer Abbey granted permission to carry away "all metals and treasures" on their lands on the banks of the Mawddach and its tributaries and in Penrhyn Llyn.[28]

5.1.4 Early Modern mining

The early Modern period saw considerable investment in continental metalliferous mining, until the wars of religion and the influx of cheap ores from the slave-economies of South America put paid to their prosperity. To this period belong many innovations that were to hold sway into the twentieth century, such as railways,[29] the

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[19] W.O. Stanley, "Note on Great Orme and Parys Mountain Copper Mines" *Archaeological Journal* 7 (1850) pp. 68-9.

[20] O. Davies, "The Copper Mines on Great Orme's head, Caernarvonshire" *Archaeologia Cambrensis* vol. C, part 1, (1949) pp. 61-66.

[21] John Pickin, "Stone Tools and Early Metal Mining in England and Wales", *Early Mining in the British Isles* (Maentwrog, 1990) pp. 39-42.

[22] Janet Ambers, "Radiocarbon, Calibration and Early Mining", *Early Mining in the British Isles* (Maentwrog, 1990) pp. 59-63.

[23] L.A. Dutton, "Prehistoric Copper Mining on the Great Orme", *Proceedings of the Prehistoric Society* 60 (1994) pp. 245-286.

[24] D. Jenkins, "Mynydd Parys Copper Mines" *Archaeology in Wales* 35 (1995) p. 35.

[25] S. Timberlake, "Archaeological and Circumstantial Evidence for Early Mining in Wales" *MbP* pp. 138-9.

[26] J. Bennett, R. Vernon, *op. cit.*, 1993 p. 98.

[27] Pers. comm., Robert Vernon.

[28] K. Williams-Jones. "Llywelyn's Charter to Cymer Abbey in 1209" *JMHRS* vol. III part 1 1957 pp. 45-78.

[29] M.J.T. Lewis, *Early Wooden Railways* (London, 1970), *passim* - though Dr Lewis now believes that there is evidence for the existence of earlier rut-ways in European mining, and it is possible that evidence will emerge for the continuous use of this type of technology from the Roman period.

application of waterwheels to force-pumps by flatrod systems in the 1540s,[30] and explosives (from 1627 at Banska Stiavnica [Shemnitz]).[31] Tudor attempts to make the British Isles self-sufficient in mineral resources led to German miners making their way to established centres of mining in the Pennines and in Cardiganshire, but Gwynedd lay largely neglected. Robert Dudley, Earl of Leicester, appointed Ranger of the Forest of Snowdon in 1574, may have begun to re-work the old mines of Creuddyn and Llangelynin in this period,[32] whilst Sir John Wynn of Gwydir engaged the great mathematician Thomas Harriot to assay ores from his Cae Coch mine.[33] His son carried on a trade in lead ores with Hamburg, and some work seems to have continued until the estate passed into English hands in 1689.

5.1.5 Modern mining

The modern period of metalliferous mining in Britain is characterised by the dominance of Cornwall in copper and tin, which led to Cornishmen exporting their mining skills to all areas of Britain and beyond,[34] as well as by the brief ascendancy of Mynydd Parys in copper.

The immediate boost to copper mining in the eighteenth century came with the increasing use from 1761 of copper sheathing of naval vessels; Cornish ores, smelted in South Wales and worked up by smiths in Birmingham or Bristol had been usurping the place of German ores since the beginning of the century, and in 1750 the Cheadle Brass Company took to smelting some of its ores at Greenfield near Holywell in north-east Wales, a site that offered abundant water-power near the coast.

It was not long before local ores were making their way there; Drws y Coed was active again from 1761 in the hands of Cornish adventurers, copper was being worked at Llanberis, and from 1764 the Macclesfield Company of Charles Roe was at work at Penrhyn Du on Llyn, where the land belonged to Sir Nicholas Bayley, part-owner of Mynydd Parys on Anglesey. The discovery of low-grade copper ore near the surface, combined with the entrepreneurial skills of the lawyer Thomas Williams, led to Parys becoming the most productive copper-producing area in the world for a number of years, forcing the established Cornish industry to mine ever-deeper and to invest in progressively more sophisticated pumping machinery. Smelters were established at nearby Amlwch and further afield, at Ravenhead, Swansea and Liverpool; a copper forge, a wire mill and a rolling mill were established at Holywell. Ochre and sulphur were all produced near the mines themselves. By 1800 Thomas Williams was conducting half the copper industry of the United Kingdom.

The glory days of the Anglesey copper industry did not outlast the recession which followed the battle of Waterloo, and throughout the century families which had worked in the mines were abandoning Amlwch for Blaenau Ffestiniog and elsewhere to find work in the slate quarries. Deep mining ceased towards the end of the nineteenth century.

However, its short-lived prosperity had attracted investment in copper in mainland Gwynedd in the late eighteenth century, and even after Mynydd Parys' decline began, the Arfon copper mines continued to be worked, those near Llanberis and in Dyffryn Nantlle exporting through Caernarfon, those on the southern slopes of Snowdon and around Beddgelert sending their produce to Traeth Mawr, and later to Porthmadog. On the Great Orme, mines which had been revived in the seventeenth century enjoyed a temporary prosperity until the 1850s, when the Mostyn estate took the decision to develop the area as a tourist resort.

Further south, in Merioneth, copper working resumed in the eighteenth century and more particularly after the Napoleonic Wars, employing as many as 265 men as late as 1861 - more than in Caernarfonshire at the time. The discovery of gold in this area in 1844 led to the first Merioneth gold rush, five years before gold was found at Sutter's Creek in California, seven years before the Australian gold rush. In 1857-8 the defunct Figre (Vigra) and Clogau mines were bought up, and gold discovered there in 1859, yielding enormous dividends and leading to the second gold rush, of 1862.[35]

Lead, which had been little mined in Gwynedd compared to the workings in North-east Wales in the eighteenth century, came into its own in the mid-nineteenth century, with the revival of mines near Dinas Mawddwy, at Llanengan on Llyn, in Llanfachreth in Merionethshire and on the Gwydir estate in Dyffryn Conwy. By the end of the century this last had become one of the most productive lead-mining areas in the United Kingdom, outlasting

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[30] G. Holister-Short, "The First Half-century of the Rod-Engine" *MbP* p. 84.
[31] G. Holister-Short, "The Introduction of Powder" *MbP* p. 148.
[32] J. Bennett, R. Vernon, *Mines of the Gwydyr Forest* 2 (Cuddington, 1990) p. 15.
[33] D.Rh. Gwyn, "Early Mineral Assaying in Dyffryn Conwy" *GD/IG* 1 1996 pp. 22-25.
[34] R. Burt, *The British Lead Mining Industry* (Redruth 1984) pp. 193-9.
[35] G. Hall, *The Gold Mines of Merioneth* (Kington, 1988) pp. 31-5.

the Van mine, north of Llanidloes, and outstripping the Cardiganshire lead field, with working continuing into the twentieth century at Aberllyn and Parc.

The rush of capital into North-west Wales in the 1850s, '60s and '70s reflected the bubble nature of the industry throughout the United Kingdom, when mining shares became a music-hall joke and which later was to be satirised by Daniel Owen in his novel *Enoc Huws*.[36] To this period belong some of the most fraudulent organisations, such as St Pierre Foley's Mining Company of Wales, which took over a number of hopeless sites and promised great things for them in 1850. The readiness of the investing public to buy mining shares in this period beggars belief, even when allowance is made for a naive new generation of would-be capitalists putting their hard-won disposable income into what they hoped would be a second Devon Great Consols. Outrageous misuse of shareholders' cash persisted well into the twentieth century; in 1920 Joseph Aspinall sprayed an adit of Klondyke mine with lead concentrates to impress the dowagers and Indian undergraduates whom he persuaded to take shares in this "enormous deposit of pure virgin silver."[37]

Ironstone has been extracted at a number of locations within Gwynedd; the Cross Foxes mine appears to have been at work by 1717, supplying the furnace at Dolgun, and other mines were opened and near Betws Garmon in the nineteenth century, and at Llandygai in the twentieth.[38]

At a considerable number of locations, specific short-term needs caused mines to be opened. Manganese had been worked in Llyn and Merioneth from the mid-nineteenth century to make bleach and glass, but the the superior quality of German steel appeared to be due to manganese present in the ore, a discovery which led to the controlled use of the metal in British steel production to harden components. The failure of production in Russia as a consequence of the war with Japan gave fresh impetus to the Welsh industry. The urgent needs of heavy engineering in two world wars for this metal caused mines to be opened and worked intensively for short periods.[39]

From Cae Coch in Dyffryn Conwy, the scene of Sir John Wynn's trials in the seventeenth century, pyrites were being sent to the Lancashire chemical industry from perhaps the 1790s; from 1917 to 1918 it was intensively worked by the Ministry of Munitions and from 1941 to 1942 by the Ministry of Supply.[40]

5.2 Archaeological Summary

5.2.1 Workings

This category includes the means by which the ore and gangue were extracted from the vein, and the tips that are thereby formed.

5.2.1.i. Pre-Modern

Archaeological evidence points to widespread Prehistoric exploitation of copper ore in Gwynedd by means of stone tools. On the Great Orme these are known to have been used in conjunction with organic tools associated with both fire-setting and primitive hard-rock mining, in opencast workings and underground.[41] At present it is only in Gwynedd that there is evidence for insular underground mining in the Bronze Age, with possible gallery mining at Trecastell, Pant y Gaseg and Pant yr Eidal, and confirmed gallery extraction at the Great Orme and Mynydd Parys.[42] It is possible that opencasts at Llanberis Mine may date to the Bronze Age.[43]

There is no evidence for the use of prospecting or extractive hushes within Gwynedd, such as were used in a pre-Modern context at Dolaucothi and at Cwm Ystwyth (though see 5.2.3.i. below).[44]

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[36] D. Rowlands, *Profedigaethau Enoc Huws* (Denbigh, 1891; argraffiad newydd, Hughes a'i Fab, Caerdydd, 1995).
[37] J. Bennett, R. Vernon, *MGF 6* (Cuddington, 1995) pp. 90-101.
[38] F.J. North, *Mining for Metals in Wales* (Cardiff, 1962) pp 86-87.
[39] F.J. North, *Mining for Metals in Wales* (Cardiff, 1962) pp. 98-100.
[40] J. Bennett, R. Vernon, *MGF 7* (Cuddington, 1997) pp. 29-39.
[41] L.A. Dutton, "Prehistoric Copper Mining on the Great Orme", *Proceedings of the Prehistoric Society* 60 (1994) pp. 245-286.
[42] J. Pickin, "Stone Tools and Early Metal Mining in England and Wales" *Early Mining in the British Isles* (Maentwrog, 1990) p. 41.
[43] D. Bick, "Llanberis Copper Mine and its Antiquity" *Archaeology in Wales* 28 (1988) p. 85.
[44] D. Austin and B.C. Burnham, "A new milling and processing complex at Dolaucothi: some recent fieldwork results", *Bulletin of the Board of Celtic Studies* 31 (1984) pp. 304-313, S. Hughes, "The Hushing Leats at Cwmystwyth" *MbP* pp. 48-53.

As yet, no archaeological evidence has emerged for Roman or Medieval metalliferous mining in Gwynedd. At Drws y Coed copper mine two of the higher adits are believed to be coffin-section, traditionally associated with Roman mining techniques but appropriate to any mine where miners carry ore and waste in bags over their shoulders. The proximity of the Cae Mawr mine near Betws y Coed to the fort at Bryn y Gefeiliau strongly suggests Roman exploitation but evidence is lacking.

5.2.1.ii. Modern

Within the Modern period several types of extraction-point were noted.

Open quarrying was encountered at a number of locations, pride of place going to the Great Opencast at Mynydd Parys, where the enormous deposits, initially to be found within a few feet of the surface, made this a practical method. Ironstone was also found to have been quarried from open pits in Gwynedd, as in other locations in the United Kingdom. At Cross Foxes a substantial opencast was observed, and also at Ystrad and Garreg Fawr, near Betws Garmon, where the workings also resolve themselves into a rabbit-warren series of openings higher up the hillside, following the outcrop of the dipping beds.

Most sites, however, were worked underground. In the Modern period the tendency is for entries to become larger and more substantial. By far the most common means of reaching the vein was by means of a level tunnel, referred to here as an adit (see plate 3). These are for the most part simple openings in the rock, though occasionally a brick or stonework arch is found where they entered sediments or soft rock. Typical of eighteenth and early nineteenth century practice in their apparently random and unconnected fashion of working, are the adits at Drws y Coed, whose value is enhanced by the primitive cobbing shelters immediately outside them (see 5.2.2.ii. below). Here adits, stopes and shafts were noted in a confined area.

Others, such as at Parc, are known to have been sufficiently large to accommodate a locomotive and a run of substantial mine wagons. In general, however, they are small, sufficient to accommodate a barrow or perhaps a hand-trammed railed vehicle, to a gauge of between 1'7" or 2'2". Though no attempt was made to explore these beyond the adit mouth, an exception was made for the Ty Gwyn adit at Llandudno, whose entrance has been blocked, but which is accessible from a man-hole on the Promenade. This survives in excellent condition for 600m., complete with *in situ* wooden strap-rail and the solidified traces of clog-prints in the mud, a remarkable survival, typical of early nineteenth century practice. Branch levels give access to an engine-shaft.

The practice of stoping - workings upwards through the vein from the tunnel, frequently reaching daylight - was commonly encountered in workings of all descriptions.

Shafts were frequently encountered, to allow the circulation of air, for uphaulage and for pumping. Air shafts have no distinguishing features at the surface. For uphaulage, it appears that the hand-windlass was very frequently employed in Gwynedd mines, though horse-whim circles survive at Llwyndu and Clogau, where a particularly well-preserved example survives next to the housing for the steam-engine which is believed to have replaced it (see 5.2.3 and 5.2.4 below, and plate 4). There is abundant bibliographic and archival evidence for the use of headframes and a mechanical prime-mover for uphaulage at some of the larger mines, but no examples have survived intact. Cwm Ciprwth mine preserves a water-wheel with a haulage drum, recently consolidated, and a kibble, but the shaft-head gear has vanished (see 5.2.3.ii below).

Shafts used for pumping, commonly referred to in nineteenth century sources as "engine shafts", were encountered at a number of locations. They are frequently indistinguishable from haulage shafts in terms of their archaeology, though sometimes it is possible to see the trace of a flatrod system leading to them, as at Simdde Dylluan and Cyffty, or parts of the pump-rod itself, as at Ty Gwyn, or an angle-bob base. In the case of Cwm Ciprwth, the equipment survived sufficiently intact for it to be reconstructed by the Snowdonia National Park. In one instance, Berth Lwyd gold mine, it was possible provisionally to identify a pump-shaft by the trace of a stone-lined conduit from the shaft-head to the river.

Two other methods of extraction deserve comment. The system of precipitation extensively practised on Mynydd Parys, and which went on until 1958, is not unique to this site, as has sometimes been claimed. It was a feature of the Cronebane mine in County Wicklow, in lease, like Mynydd Parys, to Messrs Roe, who seem also to have tried it at the Llanberis mine, though there is now no visible evidence of the method here, certainly nothing equal to the extensive series of shallow brick-lined pits covering many acres, which remain a distinctive feature of Mynydd Parys. The pits allowed copper-impregnated water to react with iron in the pits to precpitate metallic powder, which is then removed to be roasted and smelted.

The extraction of copper-ore from turf was practised at a number of sites, primarily the Dolfrwynog turf works in

Llanfachreth. The system involved burning copper-impregnated turf in a kiln, in the hope that it would yield sufficient ore to be worth smelting, a method that may have been used locally in the Roman period and in late Prehistory to provide iron ore for smelting. It is also possible that precipitation was practised here.

The spoil heaps left by extraction processes constitute a vital part of the archaeology of mining. Their shape frequently indicates the method of transport used in the mine (see *5.2.4.*), and their size and composition are valuable indicators not only of the source underground but also of the process of extraction and dressing. In a number of places, such as at Hafna, tips were observed to have been reclaimed without adequate evaluation.

5.2.2 Processing

Dressing of the ore to yield useful and saleable metals was observed to have been carried out variously by three separate types of operation, namely mechanical processing, processes dependent upon physical properties and by processes dependent upon chemical properties. The individual methods of processing ore within each of the three categories are discussed below in order within the pre-Modern and Modern periods.

5.2.2.i. Pre-Modern

The archaeology of pre-Modern ore-processing is little understood. There is, however, some evidence for two types of operation. Mechanical processing may be represented by some hammer-stones; it is possible that they were used not only as mining tools but also had a secondary role in the primary reduction of ores.[45] This category also comprehends ore-washing; water is known to have been used for concentration in Prehistory, and early wet dressing sites have been suggested on the Great Orme, at Ffynnon Galchog and Ffynnon Rhufeinig.[46]

Methods dependent on chemical properties are represented by the possible copper smelter which has been identified at Pen Trwyn on the Great Orme. This has been investigated by Gwynedd Archaeological Trust with grant-aid from Cadw.[47] Coincidentally, a possible Bronze Age smelting site has also recently been excavated at Alderley Edge in Cheshire.[48] Iron smelting sites from late Prehistory or the Romano-British period have been identified at a number of hillforts and hut-circles but none is associated with any evident mine workings, and it is possible that the ore was derived from turf-smelting.[49]

5.2.2.ii. Modern

A wide variety of different processing methods was found to have been employed to process the different types of ore in the Modern period, and increasingly by the late nineteenth century the trend was towards large gravity-assisted processing sites on the side of hills in which a combination of processes from all three categories might be employed.

Some sites, the manganese mines in particular, show no evidence at all for processing having taken place, and it is clear from documentary evidence that this is a feature of manganese extraction world-wide.[50]

Otherwise, mechanical processing in one form or another is evident at practically every site, and small mines would often make use of no other system.

Mechanical processing comprehends washing of ore to remove impurities. In its simplest form, the prospecting pan, this method is known to have been widespread in the gold workings of Merioneth, and sieving was practised in manganese mines. There is documentary evidence for ore-washing at a number of sites,[51] and archaeological evidence for the use of jobbing buddles at Gamfa Fawr in Gwydir.[52]

Hand-bucking and cobbing of ore was clearly practised at lead, copper and gold-mining sites in Gwynedd well into

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[45] S. Timberlake, "Excavations at Parys Mountain and Nantyreira" *Early Mining in the British Isles* (Maentwrog, 1990) p. 21.

[46] S. Jones, *Deciphering the "Metallic Arts" of the Bronze Age* (M.A. in Archaeological Practice, University of York, 1994), Emma C. Wager, *An Assessment of the Evidence for Prehistoric Copper Ore Processing at the Site of Ffynnon Rhufeinig* (M.Sc., University of Sheffield, 1996).

[47] Gwynedd Archaeological Trust, *Report* (forthcoming).

[48] Personal communication, David Wagstaffe, Pandy Parc, Llandyfrydog, Ynys Môn.

[49] S. Timberlake, "Archaeological and Circumstantial Evidence for Early Mining in Wales" in *MbP*, pp. 133-143.

[50] C. leN Foster, S.H. Cox, *Ore and Stone Mining* (London, 1910) p. 669.

[51] Such as, for instance, at Moelwyn zinc mine; see R. Owen, "The Moelwyn Zinc Mine: My Memories of the Moelwyn Mine" *Ffestiniog Railway Heritage Magazine* 43 (Autumn 1995) pp. 13-25.

[52] J. Bennett, R. Vernon, *MGF 3* (Cuddington, 1991) p. 23.

the twentieth century, and evidence survives at a great number of locations, though perhaps most clearly at Braich yr Oen and Drws y Coed, in the form of small shelters or *cabannau*, sometimes with a bench for the cobbers. Other good examples survive at Gamfa Fawr, Pen'rallt and South Pandora at Gwydir. At Drws y Coed these features survive alongside the many adits referred to in (5.2.1.ii.) above, and greatly add to the archaeological significance of this element in an outstanding site.

Evidence of mechanical crushers was encountered at a great number of sites, sometimes in the form of the stone-built crushing-houses for these machines, sometimes, as at Cwm Erch, Britannia and Cywarch, in fragments of machinery surviving. The Britannia crushing-house and the Vale of Conway Mine crushing-house have both been recently consolidated. Most commonly fluted rolls were used, though there is some archaeological and considerable archival evidence for the use of jaw and gyratory breakers. At Red Dragon Mine, the base of a Perkes machine was observed, recently consolidated by the Welsh Mines Society, an extraordinary contraption which was part gyratory breaker and part amalgamation machine (fig. 7). The mechanical component involved six conical rollers each weighing four tons rattling inside a 12' diameter cast-iron chamber,[53] though curiously the whole device sat on a plinth within a conventional crusher-house, even though no other machinery was used. The Britten pan was another machine which combined mechanical crushing and amalgamation; none survives *in situ*, but an example from Bedd y Coedwr mine has been preserved and put on display at the Coed y Brenin Forestry Centre at Ganllwyd.[54]

The Perkes machine and the Britten pan were London-built. For much of the nineteenth century the documentary evidence suggests that North Walian firms could and did supply machinery for mechanical processing, such as DeWinton's Union Ironworks in Caernarfon, which supplied the crusher at Cwm Dwyfor.[55] Increasingly, however Green's of Aberystwyth made their mark, supplying, for instance, the Britannia Mine on Snowdon.[56] Green's main customers were based in the important Cardiganshire mining field. However, with the move to steel in the later years of the nineteenth century, it is clear that it became necessary to look to firms like Hadfield's of Sheffield for machinery, such as the jaw-breaker which survives at Britannia.

Stamps were commonly held in small wooden frames which, by their nature, tend to leave little trace, and could be assembled locally. Often their former sites are only evident as a spread of finely-crushed material and sometimes, where they were water-powered, by a channel and perhaps the pit for a small water-wheel. A half-size reconstruction has been assembled at Sygun. Occasionally these are known to have been housed in buildings, and a feature at Drws y Coed Mine has been interpreted as an eighteenth century stamp mill by Robert Vernon.[57] This has been disputed, and whilst the sites of many stamp mills are known, there is little archaeological evidence for them. The remains of an edge runner (fig. 4) were observed at Cefn Coch/Berthlwyd and at Llechfraith (Hirgwm) Mine. It is possible that what is now a dwelling at Prince of Wales Mine was formerly a stamp-tower.

Of methods dependent upon physical properties, archaeological evidence was observed for processing by means of motion in water. Round buddle pits (figure 3) survive at a number of locations, seen to best effect at Vale of Conway lead mine, Cyffty lead mine, Aberllyn lead mine and Garthgell gold mine. In the latter two cases, the pits are constructed out of concrete. Other methods, such as the use of jigs, belts and percussive tables (fig. 8) are known from documentary sources but tend to leave little archaeological trace. The remains of bases for such machines survive at Bwlch y Llu.

The third category comprehends all methods which depend on chemical properties. This is reflected in the archaeological resource in a number of ways. Atmospheric weathering and sparging with water require few structures and leave little trace. Precipitation of copper-laden water with iron was practised on a substantial scale at Mynydd Parys, and the series of ponds which the process required covers many acres. It is known to have been practised at Llanberis,[58] but no archaeological evidence is apparent.

Evidence of calcining kilns (in which the ore is roasted to remove sulphur before smelting), was observed at Mynydd Parys, Aberllyn and Trecastell. At the tiny Ceunant Mine in Dyffryn Ogwen, lengthy arsenic flues were noted, though there is no visible evidence of a furnace. Amalgamation of metal (see **8. Glossary**) is known from documentary evidence to have been extensively practised in the Merioneth gold industry, but it is a process which does not require any large structures.

It is only in the case of concentration plant that large buildings were necessary for any form of chemical processing.

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[53] D. Bick, *The Old Metal Mines of Mid-Wales Part 5* (Newent, 1990), pp. 18-19.
[54] This is situated at SH715277, north of Dolgellau.
[55] D. Bick, *op. cit.*, p. 31.
[56] D. Bick, *The Old Copper Mines of Snowdonia* (Newent, 1985), p. 81.
[57] R. Vernon, *Report on the Drws y Coed Copper Mine* (unpublished t.s., n.d.) pp. 13-15.
[58] D. Bick, *op. cit.*, p. 87.

The patent, taken out by Frank Elmore in 1898, is based on the fact that copper pyrite has an affinity for the surface tension effect of oil, and in an adapted form is now a commonly used method world-wide. It was first used to practical effect at Glasdir (plate 5) and at Sygun Mines in 1900, and at both sites the stepped mill bases for the Frazer and Chalmers concentrator units survive, forming impressive monuments to the technical innovativeness of metalliferous mining in nineteenth-century Gwynedd.

Alongside them must be set a number of mills which employed a variety of methods. The Klondyke mill of 1900, a component of the Gwydir mining area, a Scheduled Ancient Monument (C159), is perhaps the most spectacular, a substantial building, unfortunately becoming progressively more dilapidated, which contained breakers and rolls, possibly trommels and percussive tables, certainly buddles (plate 6). Otherwise the most impressive examples are Hafna and Aberllyn lead mines, also in the Gwydir forest, both of which used a gravity-assisted stepped system on a hillside site. At Hafna, mechanical, physical and chemical processes were used in succession on five floors, together with a tuyère furnace smelter. Some of the buildings survive on this outstanding site, which also includes an impressive brick chimney. At Aberllyn, ore was crushed, jigged and buddled on four stone-built floors, and the remains of a calcining furnace survive immediately adjacent, but otherwise little survives in the way of upstanding buildings on this site.

5.2.3 Power systems

Whilst the full variety of power-sources was certainly employed in metalliferous mines in Gwynedd, it is clear that the industry remained dependent on water-wheels and turbines in the Modern period.

5.2.3.i. Pre-Modern

Water is known to have been used for concentration in Prehistory, and early wet dressing sites have been suggested on the Great Orme, at Ffynnon Galchog and Ffynnon Rhufeinig.[59] David Bick has argued that the Precipice Walk at Dolgellau is in reality two leats connected with pre-Modern mining activites to the north, in the region of the Glasdir mine, on the analogy of the Cothi leat above Pumsaint, designed to catch rainfall and heavy snow, as with Roman mining leats in Spain.[60]

5.2.3.ii. Modern

Evidence was observed for hand-cobbing at a number of locations, particularly at Braich yr Oen and at Drws y Coed, and it is highly likely that some processing machinery was hand-operated, such as jiggers - an engraving of Melin Llyn y Pair Mine in 1870 shows the familiar wooden frames with the handles on top (see fig. 9).

In the Modern period water-wheels came to be used on many sites. At Lliwedd parts of the wheel itself survive alongside the crusher, together with some of the fluted rolls. The wheel itself, constructed by the Hawarden Iron Works, had iron shrouds and wooden strut arms and wooden buckets. At a great many locations, wheelpits survive alongside the sites of crushing plant and buddles, seen to best effect perhaps at the Vale of Conway mine in the Gwydir forest. At Drws y Coed, though the wheel-pit which powered the nineteenth-century mill has been badly damaged, the water-power system remains an impressive feature of this important site, extending for many miles to the south and to the east. At Bwlch y Llu, the bases survive of a most unusual system of supporting a water-wheel, on two concrete columns.

The sites of peltons by their nature tend to be less apparent, but impressive remains survive in the Klondyke mill, and above all at Gwynfynydd, where the substantial pipes that fed the lower mill remain *in situ*. Steam-engine bases are apparent at very few sites, though it is clear from documentary evidence that they powered a number of mills. At Hafna it is possible to see the base of a horizontal engine that powered the fans for the furnace and the rock-breakers. Internal combustion engines and electric motors leave even less archaeological evidence, and traces of the latter are generally only to be found in the shape of transformer stations, as at Cae Coch.

The most impressive remains of power-sources within the archaeological resource are those connected with

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[59] S. Jones, *Deciphering the "Metallic Arts" of the Bronze Age* (M.A. in Archaeological Practice, University of York, 1994), Emma C. Wager, *An Assessment of the Evidence for Prehistoric Copper Ore Processing at the Site of Ffynnon Rhufeinig* (M.Sc., University of Sheffield, 1996).

[60] D. Bick, "Observations on Ancient Mining in Wales" in *Early Mining in the British Isles* (Maentwrog, 1990) p. 75, "Early Mining Leats and Ponds in Wales" *MbP* pp. 38-9. Mr Bick suggests (*loc. cit.*) that such leats were used for purposes other than ore-washing or hushing, and increasingly evidence is emerging for the use of stamp-mills in the Roman period (M.J.T.Lewis, forthcoming). However, a number of other authorities disagree with Mr Bick's interpretion of this feature.

pumping, which are often accompanied by the trace of a flatrod system. Cornish expertise and salesmanship is evident, though local manufacturers are also represented. Again, water-wheels were observed to have been the most common means of operating pumps, with pride of place going to the water-wheel installed at Cwm Ciprwth in 1889-90, and recently restored by the Snowdonia National Park, a 24' diameter iron wheel, built by Dingey and Sons of Truro, and possibly bought second-hand. This connected with a force-pump by means of timber flatrods and an angle-bob. No other pump-wheels survive in Gwynedd, though flatrods formerly driven by them are believed to remain *in situ* underground at Catherine and Jane Consols. Over the Great Orme there are clear traces of the flat-rod system that ran from Ffynnon Gogarth to the mine, as well as some evidence of the Tom and Jerry engine that powered it initially, and of the collar of the shaft that fed the water-pressure engine that had taken over by 1846.[61] However, no other evidence was observed of hydraulic engines within Gwynedd, though they are known to have been used at Coed Mawr Pool, Mynydd Parys and elsewhere at Llandudno.

At Gefail y Meinars there survives part of a small water-wheel which powered a pump by means of a shaft and universal joints operating a crank and rodding underground.

Archaeological evidence of the use of steam power to pump was encountered at a number of locations, most notably at Penrhyn Du lead mine, in the form of a house for a Bolton and Watt engine (see plate 7).[62] The first steam engine in Gwynedd was situated here; a "Deed of Covenant respecting a fire engine to be erected at Penrhyn-Dee" dated 1779 survives in the Boulton and Watt archives; worn parts were replaced in 1786, and the engine was still in situ, though out of use, the following year.[63] Whilst there was a later machine on this site, it is possible that part at least of the structure dates from the late eighteenth century.[64] At Llanrwst lead mine the housing for a 25" horizontal rotary steam engine has been conserved.[65] Part of the flatrod system which this powered is believed to remain intact underground, though access is extremely dangerous.[66] A spectacular survivor is the chimney at Porth Neigwl Mine which once took the exhaust from a beam pumping-engine, and which still stands, in increasingly dangerous condition, overlooking the village of Llanengan.

There is comparatively little evidence of the use of steam engines for winding. At Catherine and Jane Consols the lower part survives of a house for a rotative beam engine by the Perran Foundry in Cornwall that clearly operated a haulage drum as well as flatrods,[67] and at Old Clogau the housing survives for a steam engine that replaced a horse-whim to haul a kibble up a shaft. There is no evidence for the use of steam-powered cages such as were a feature of metalliferous mines in north-east Wales, such as at Halkyn and Minera.[68]

5.2.4 Transport

Transport facilities within metalliferous mines in Gwynedd were observed to take various forms.

At its most basic level, transport of ore to be processed might be carried on miners' backs down footpaths. A considerable number of sites were observed in which adits were reached by transport systems no more complicated than this, and they are by no means exclusively a feature of ancient workings. Pack-animals were also widely used. Barrow-ways, or roadways for sledges or horses and carts were also observed at a great many sites. Spoil tips are only infrequently of the "finger-tip" type, which denotes the use of a railway, and the inference is that at the majority of sites in Gwynedd spoil was tipped by barrow. This does not necessarily preclude the use of a railway in the adit, as the nature of the material is such that it can be easily shovelled from a railed vehicle to a barrow. In a number of cases, such as at Lliwedd, rails survive at the adit mouth, here T-section in wrought-iron chairs, or at Ty Gwyn, where wooden rails with iron straps survive *in situ*, an excellent example of this transitional form of railway technology.[69]

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[61] C.J. Williams, *Great Orme Mines* (British Mining no 52, 1995) p. 34.
[62] D. Bick, "The Beam-Engine House in Wales" *IAR* 12 no. 1 (Autumn 1989) p. 86.
[63] Birmingham City Archives, Boulton and Watt collection, Box 27/A (agreements), 4/18/36, 4/18/35.
[64] Pers. comm., Messrs John Bennett and Robert Vernon.
[65] R. Vernon, "Conservation of Mining Sites of Gwydyr Forest, Snowdonia" *IAR* 12 no. 1 (Autumn 1989) pp. 77-83.
[66] Pers. comm., C.J.Williams, formerly of the Hawarden Record Office.
[67] D. Bick, *op. cit.*, p. 16.
[68] C.J. Williams, *Metal Mines of North Wales* (Rhuddlan, 1980) plates 24, 25, 30-31, 35-38.
[69] Eighteenth century wooden railways have recently been excavated at Ironbridge, Bersham and at Fencehouses, Tyne and Wear (see N.W. Jones, "A Wooden Waggon Way at Bedlam Furnace, Ironbridge" *Post Medieval Archaeology* 21 (1987) pp. 259-262, Stephen Grenter, "A Wooden Waggonway Complex at Bersham Ironworks, Wrexham" *IAR* 15 no. 2 (Spring 1993) pp. 195-205, and "Lambton Waggonway" *Industrial Archaeology News* 100 [Spring 1997] p. 16), and many examples of the next, wrought-iron, phase survive. However, very few examples of the part-wood, part-iron railway are known.

Railways are most evident as features within the archaeological resource as contour features, often on substantial embankments, as at Cefn Coch and Moelwyn, forming part of a transport system in which differences in altitude were overcome by a variety of means.

Railed inclines, generally operating on the counterbalance principle, were encountered on a number sites. At Gwynfynydd gold mine a substantial formation connected the topmost and lowest working levels; at Braich yr Oen an incline, apparently laid for plate-rails, formed the first part of a remarkable arrangement which also included an unusual guided transport system to take the ore down to the Hafod y Llan mill. This last feature survives as a run of stone sleeper blocks, laid to a gauge of 4', or possibly slightly more, on a gradient of 1 in 8, and which includes a curve in the formation. Several theories have been advanced as to the form this took, including a plateway, an ore-chute and an edge railway incline. The most likely explanation is that it was an edge railway, though probably horse-operated (see plate 8).

This particular transport system, however, clearly also included an ore-slide, which was clearly a very common method of moving rock. Other instances are to be seen at the Hafod y Llan mine, on the other side of the valley - a particularly spectacular one, in which the ore fell several hundred feet - and at nearby Sygun. They are known from the evidence of a painting of Llanberis mine,[70] and doubtless at one time many other sites as well. In every case, the timbering has vanished, leaving only the stone-built supports.

A method that clearly became popular in the latter years of the nineteenth century for lowering materials downhill was the aerial ropeway. The course of such system can be clearly made out at the Klondyke mill in the Gwydir forest. Other examples are known to have operated at the Ystrad and Garreg Fawr Mines in Betws Garmon, where some of the buildings survive, and from bibliographic and archival sources at Clogau and Moel Ispri. However, much the best surviving example of such a feature is at Cwm Bychan in Nanmor, where the upper return sheave and the upper run of pylons survive, running from a processing plant up the hillside to end abruptly in an area of tiny workings that had made little progress since the eighteenth century (see plates 9 and 10).

Though aerial ropeways for the most part connected remote mine sites to processing areas, they were used for purely external transport at Rhiw mine, where they connected the workings with a pier at Porth Ysgo, and at Cae Coch, where they connected the mine to the branch line railway. However, these have left little trace - at Rhiw, the remains of the boilers which powered the steam engines which operated them, at Cae Coch a sheave, hidden in a remote and forested part of the site. They were never as common as the several other forms of external transport which were noted, and though they were not included in the survey once they left the obvious confines of the mine, it is worth noting the forms they took here.

The most common form of external transport was a roadway, which might range from a primitive cart-track to a well-engineered route suitable for a traction engine or a petrol lorry, as at Klondyke. Several mines, such as Drws y Coed and Simdde Dylluan, lay on the course of parish or turnpike roads. One remarkable road is the causeway across Llyn Llydaw, which allowed ore to be carted from the Britannia Mine, and which dates from 1853. Previously boats had been used.

A number of mines opened out on the sea-shore, as at Aberdyfi and Ty Gwyn at Llandudno, and crushed ore could be trammed straight into the hold of a vessel. The cluster of mines around Aberglaslyn and Llanfrothen were presumably developed because they lay within easy reach of the Traeth Mawr, at least until Madocks completed the Cob and left them miles inland. Other mines are known to have made use of lake transport - certainly Llanberis, along Llyn Peris and Llyn Padarn to its stockpile at Cwm y Glo, four miles to the north,[71] and Britannia, which boated its produce across Llyn Llydaw until the causeway was built. However, only at Britannia do any remains of these facilities survive, in the shape of two depressions said to be turntable hoists for loading the boats.[72] It is likely that Gwernor in Dyffryn Nantlle made use at one time of the two Nantlle lakes immortalised in Richard Wilson's famous painting, as well as perhaps Drws y Coed and Simdde Dylluan. There are several grounds for suggesting this; Margaret ferch Ifan, who boated Llanberis ore, came from Nantlle, and may have learnt her trade on her native lakes.[73] The *bing gopar* ("copper bin") at Nantlle, on the upper terminus of the Nantlle Railway, though it is situated near the turnpike, is also near the shore of Llyn Nantlle Isaf, before it was swallowed by the tips of Dorothea and Pen y Bryn quarries.

No use seems to have been made of boat levels within the mines themselves.

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[70] Watercolour by John "Warwick" Smith, Lady Lever Art Gallery, Port Sunlight LP30.
[71] Peter Crew, "The Copper Mines of Llanberis and Clogwyn Goch" *TCHS* 37 (1976) p. 64.
[72] N.C. Beck, "A Brief Account of the Copper Mines in Cwm Dyli, Snowdonia" *TCHS* 31 (1970) p. 49.
[73] Pers. comm., Dr Gwynfor Pierce Jones.

Some mines made use of local railways, and in some cases only came into being because railed transport was available, as at Ystrad and Garreg Fawr mines in Betws Garmon, when the North Wales Narrow Gauge Railway turned up. Moelwyn Mine near Tan y Grisiau had its own incline connection to the Ffestiniog Railway, and Catherine and Jane Consols Mine, though it contemplated an incline to the Ffestiniog, never progressed beyond carting to Penrhyndeudraeth station. Cwm Dwyfor Mine in Cwm Pennant was served by the Gorsedda *(sic)* Junction and Portmadoc Railways, and was the only copper mine in Gwynedd to have the advantages of both direct railway access from the processing area to a harbour and steam traction, yet in its history it produced insufficient ore to fill a single train.

Purpose-built railways are few. The New Pandora mine had a railway two miles long to connect it to the Klondyke mill, constructed *c.* 1900 and operated from 1904 by a very early petrol locomotive. Much of the trace survives. The Benallt Mine had a two-mile long 3' gauge railway to connect it to a jetty, built in 1904, initially horse-operated, but which acquired two steam locomotives, one *c.* 1905 and the other in 1907. These were the only steam locomotives owned by a metalliferous mine in Gwynedd, and the course of this railway includes an impressive winding-drum for a counterbalance incline at SH215279.

The cluster of mines on Penrhyn Llyn enjoyed their own railway access for a number of years, in the form of a 3' gauge horse-worked line that ran on a suspiciously well-built course, a piece of engineering more substantial than the output of the mines' output required, and it is possible that this railway was built in order to be bought out (at, presumably, a handsome profit) should Brunel's schemes for railways in this part of the world have come to fruition.

5.2.5 Ancillary structures

Ancillary structures were noted at all but the smallest sites. At Mynydd Parys both the Parys and the Mona mines had their own quadrangular office complexes, though there is little attempt at decoration, perhaps remarkably for mines which were much visited and prosperous enough to afford a polite structure. The only instance of an ornamental structure of this type is the octagonal "offis gocyn" at Llanberis, shown on a photograph of the 1870s,[74] but long obliterated. Small unadorned office buildings were frequently encountered, including the office at Drws y Coed mine which later became the Independent chapel and was damaged by a boulder falling on it.

Smithies were an essential feature of any mine, and it is only the very smallest where there is no evidence for such a structure, often part of a larger range. A particularly fine example is the smithy at Garthgell gold mine near Bont Ddu, with an unusual curtain wall porch.

5.2.6 Domestic structures

Where there was an existing density of population, as in Dyffryn Conwy, there seems to have been no need to build special accommodation for miners and their families, who seem to have lodged on nearby farms or made the trek from the village of Trefriw every day. Some other former mining communities are long-standing; Llandudno was a community of copper miners and fishermen long before it became a holiday resort, and the pre-nineteenth century village survives as an arrangement of apparently haphazard streets, which contrast markedly with the Victorian grid-pattern down the hill, as well as in the consciousness of its inhabitants as forming a separate community from the hoteliers and shopkeepers.

On-site domestic structures are a common feature, by no means confined to the more remote workings. Though dwellings were noted at upland sites such as Cwm Dwyfor, and Llwyndu (Crib Ddu), they were also to be found at Sygun, near the village of Beddgelert, and at Mynydd Parys, where in the late eighteenth century houses seem to have been built on or near the mine sites just as they were also being put up at nearby Amlwch. Near the Drws y Coed and Simdde Dylluan mines, where there were no existing centres of population for several miles, a village came into being in the early years of the nineteenth century, consisting of two streets and a chapel as well as perhaps a smithy and a stable and a communal building which may have been a bake-house or kitchen. The houses of this remarkable community have been described by Jeremy Lowe's *Welsh Industrial Worker's Housing*, and consist of single-cell dwellings without a *crog-loft*, divided into two rooms by a wooden partition, and appear to date from between 1815 and 1836.[75] These buildings are of great importance in showing the development of an industrial vernacular[76] form of housing within Gwynedd, and as an example of a relatively undisturbed pre-Victorian industrial settlement.

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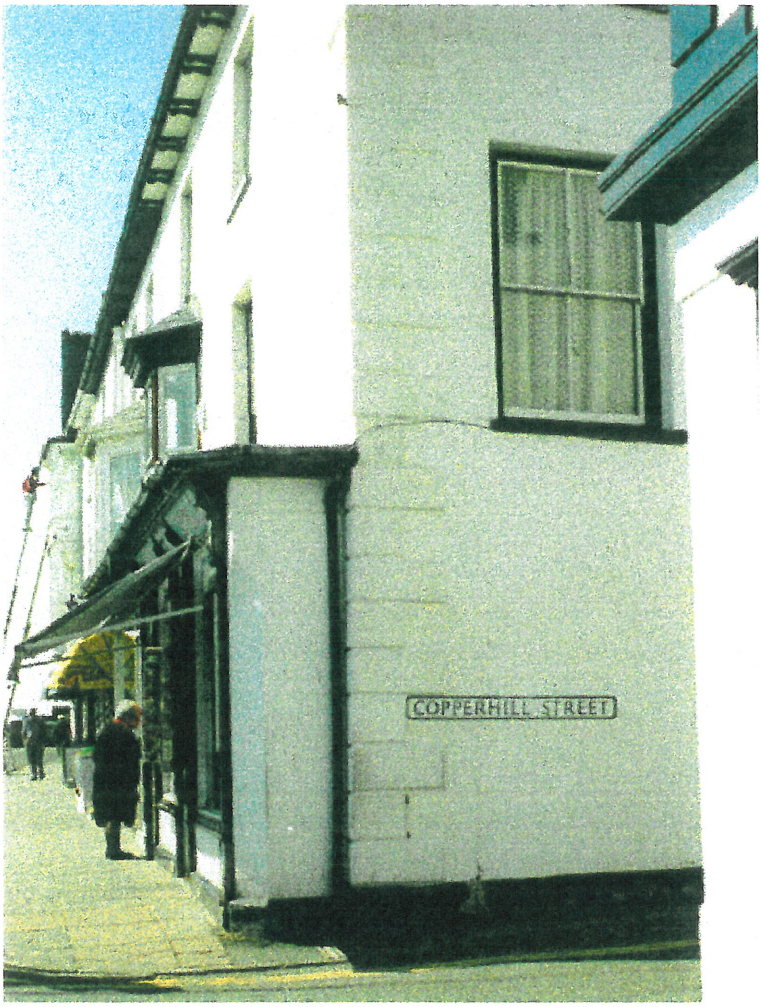
[74] Anon, "Llanberis Copper Mine" *Archive* 4 , pp. 28-9 (copy also in CRO as XS 621/72).

[75] J. Lowe, *Welsh Industrial Workers' Housing* (Cardiff, 1989) p. 11.

[76] See Judith Allfrey and Catherine Clark, *The Landscape of Industry: Patterns of Change in the Ironbridge Gorge* (London and New York, 1993) pp. 169-198.

For the most part all these buildings appear to be two-room single-storey cottages. A far more elaborate structure is to be found at Hafod y Porth copper mine, described in 1873 as "Managers Residence, Office, Smithy & Store Room" with a nearby "Miners Barracks", and at Moel Ispri a large dwelling is believed to have been occupied by the white-collar staff.



1 Many sites have disappeared completely on the surface; Copperhill Street in Aberdyfi is the only visible testament to the Balkan Hill Mine. (PRN: 2144)

2 Pant y Gaseg Mine was the scene of Prehistoric working, of nineteenth century operations and of a trial in the 1930's. (PRN: 21918)

3 The St David's Mine at Clogau. (PRN: 21897)

4 This horse-gin circle and steam-engine house illustrate two successive means of raising the ore at Old Clogau Mine. (PRN: 21874)

5 The Elmore concentration system was the prototype of ore-processing methods now used world-wide, and was developed in Gwynedd. This is the pioneering installation at Glasdir. (PRN: 20871) (DRO: ZS/53/SS)

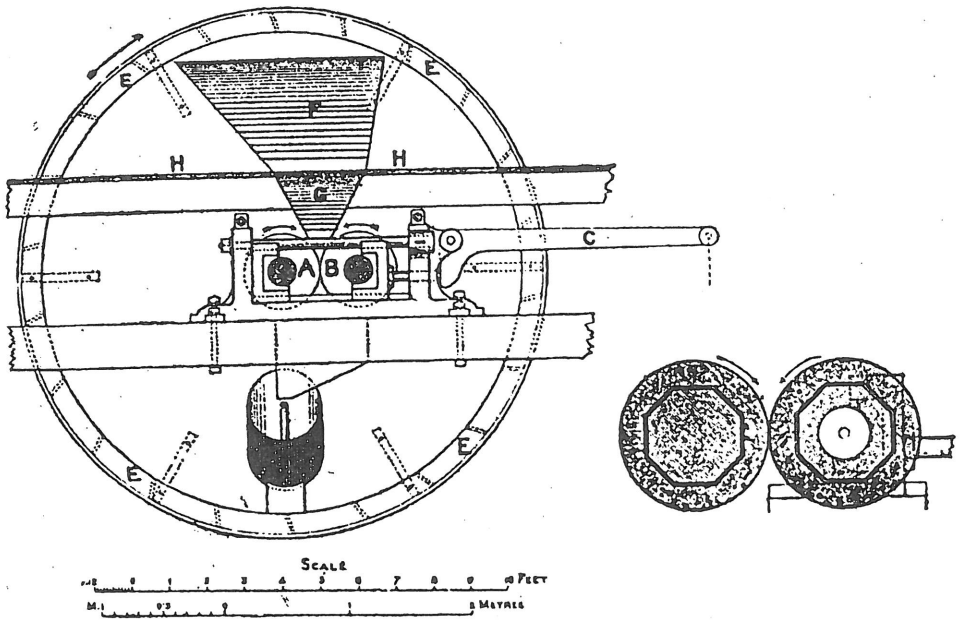
6 The Klondyke Mill (PRN: 4639) in the Gwydir mining area has deteriorated significantly over the last few years.

7 The beam-engine house at Penrhyn Du lead mine (PRN: 4729) may date in part from the late eighteenth century.

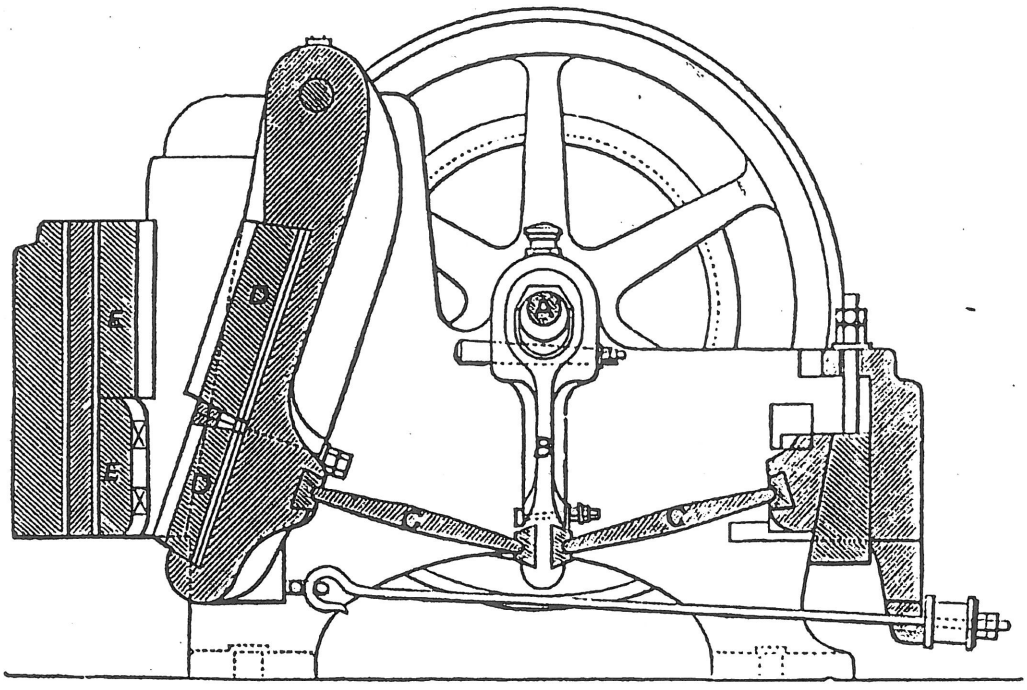
8 Braich yr Oen copper mine (PRN: 21536) is situated on the upper slopes of Yr Arran, south of Snowdon summit, and made use of a complicated variety of transport systems to bring the ore down to the Hafod y Llan mill (PRN: 21156) to be crushed. The course of the lowest stage, a steeply-inclined stone block tramway, is evident here.

9 Cwm Bychan Mine (PRN: 3792) made use of an aerial ropeway system to carry the ore from the mine itself to a processing area alongside the Welsh Highland Railway.

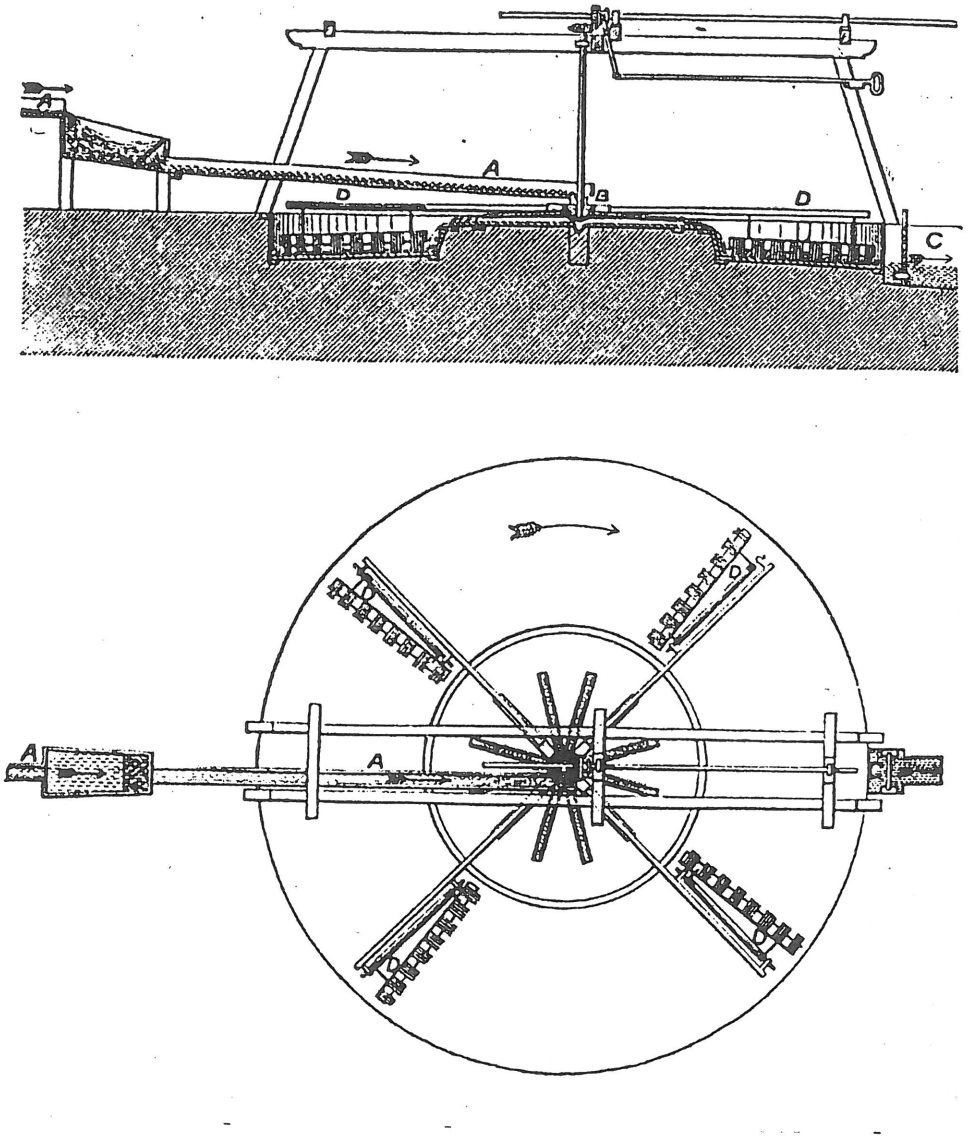
10 The ropeway terminal at Cwm Bychan Mine.



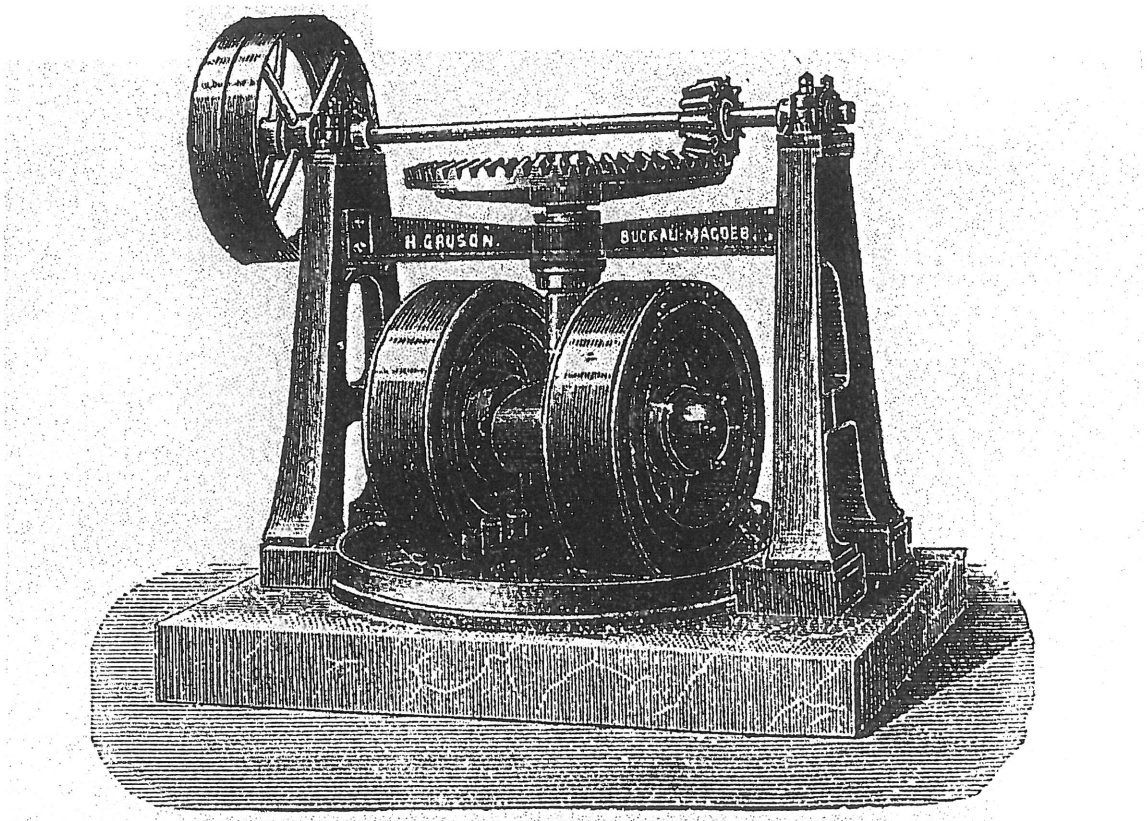
1 Roller-crushers were introduced in the early nineteenth century. Engraving from *Ore and Stone Mining* (London, 1910).



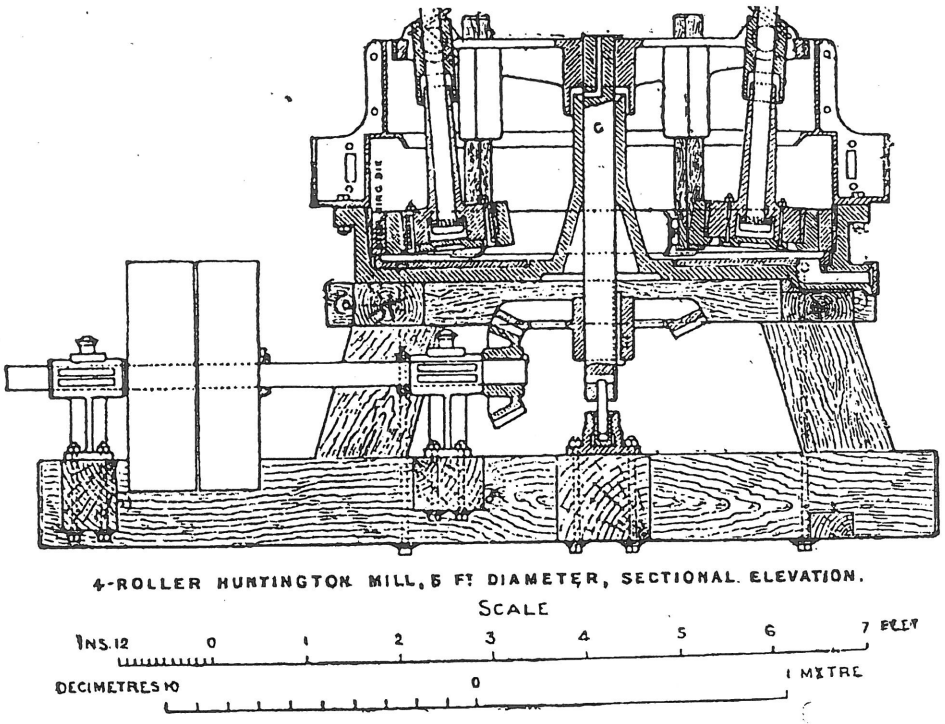
2 Jaw-breakers were introduced in the later nineteenth century; this example was maufactured by Blake's. Engraving from *Ore and Stone Mining* (London, 1910).



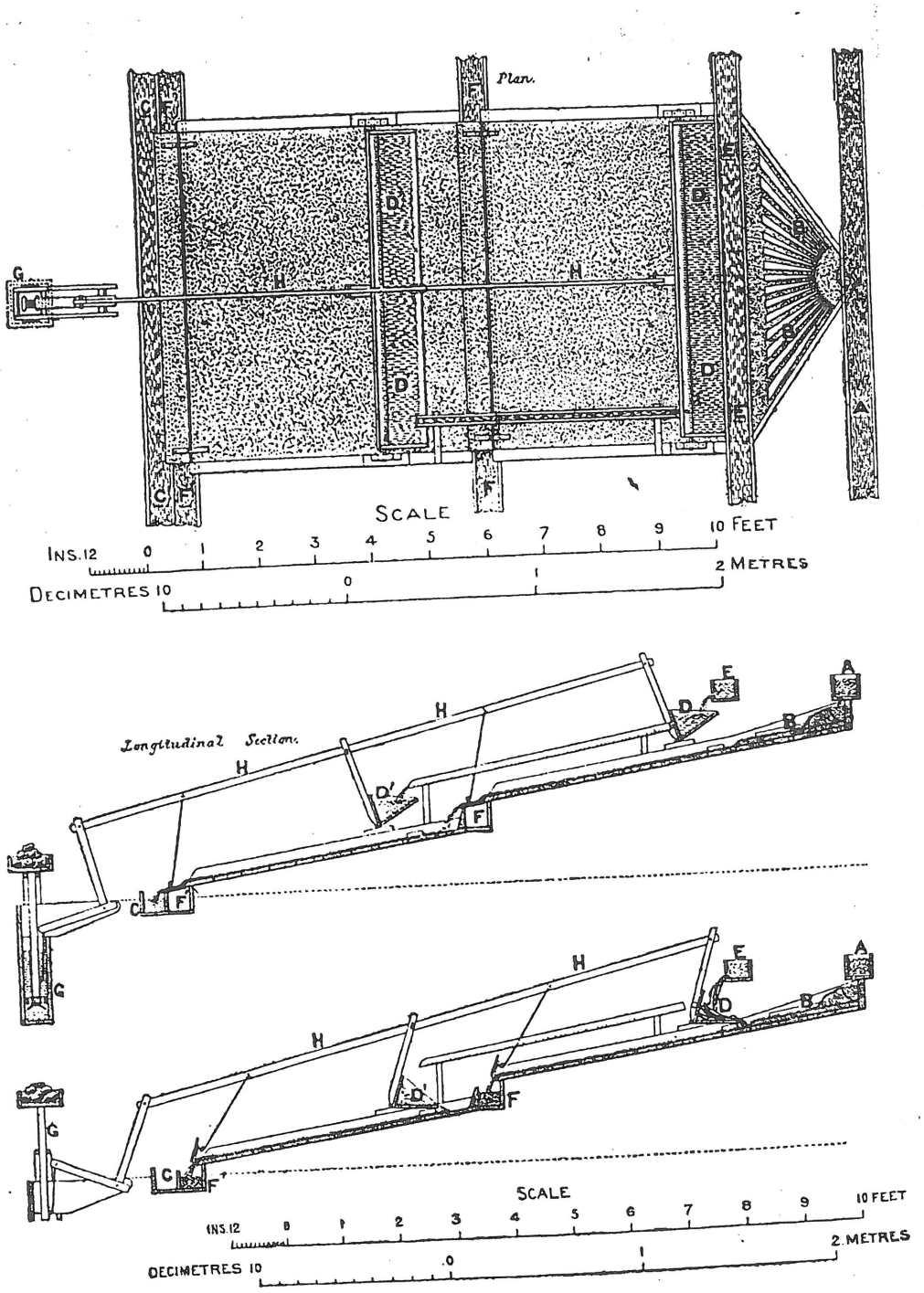
3 Pulps are fed into a round buddle by means of the channel A, and the heavier particles are deposited nearer the top, the lighter ones near the edge, the surface of the sediment being kept even by revolving brushes. Engraving from *Ore and Stone Mining* (London, 1910).



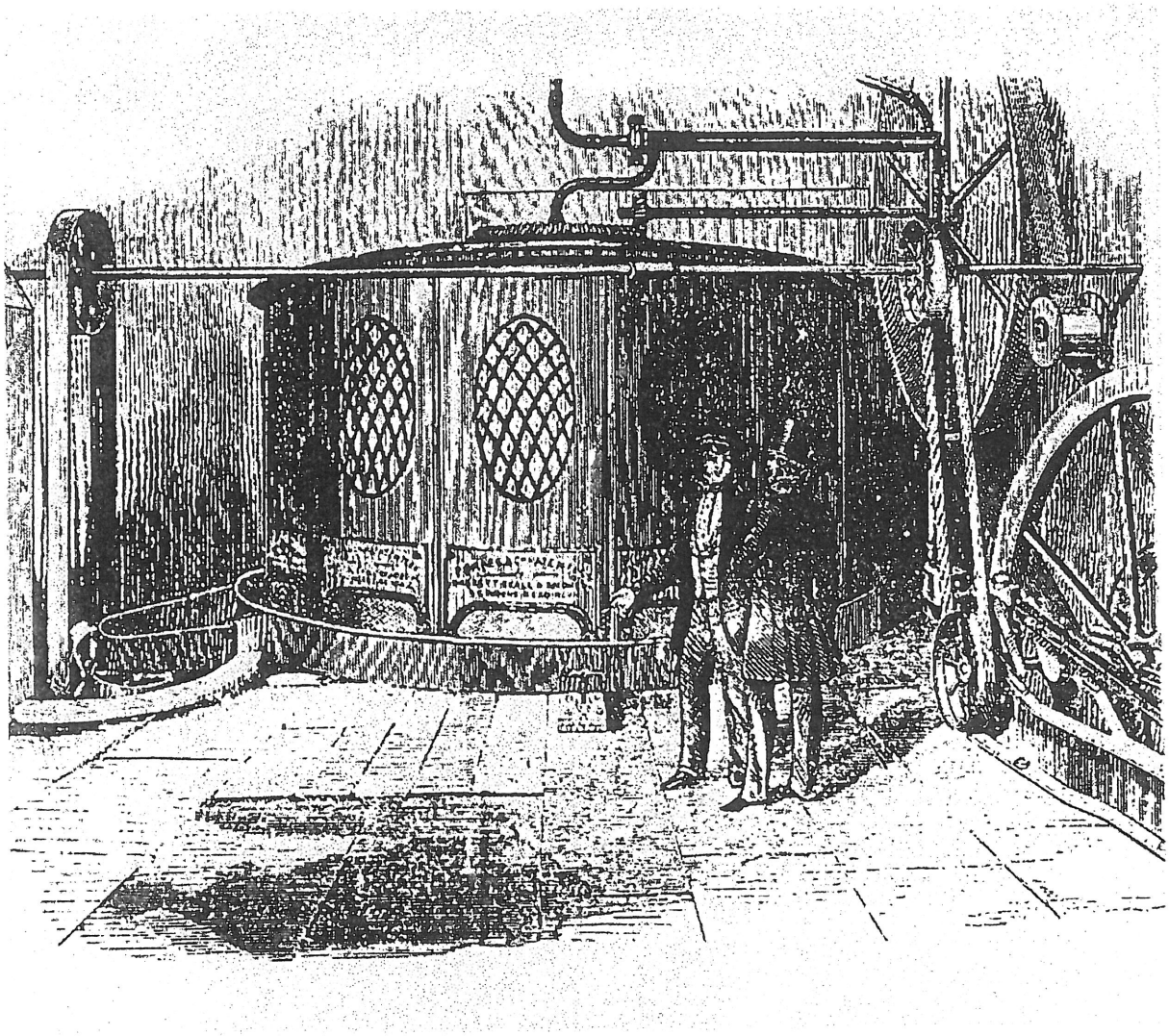
4 Edge-runners have been used to crush ore since Medieval times; mechanically-powered versions were made commercially available in the nineteenth century. From *Ore and Stone Mining* (London, 1910).



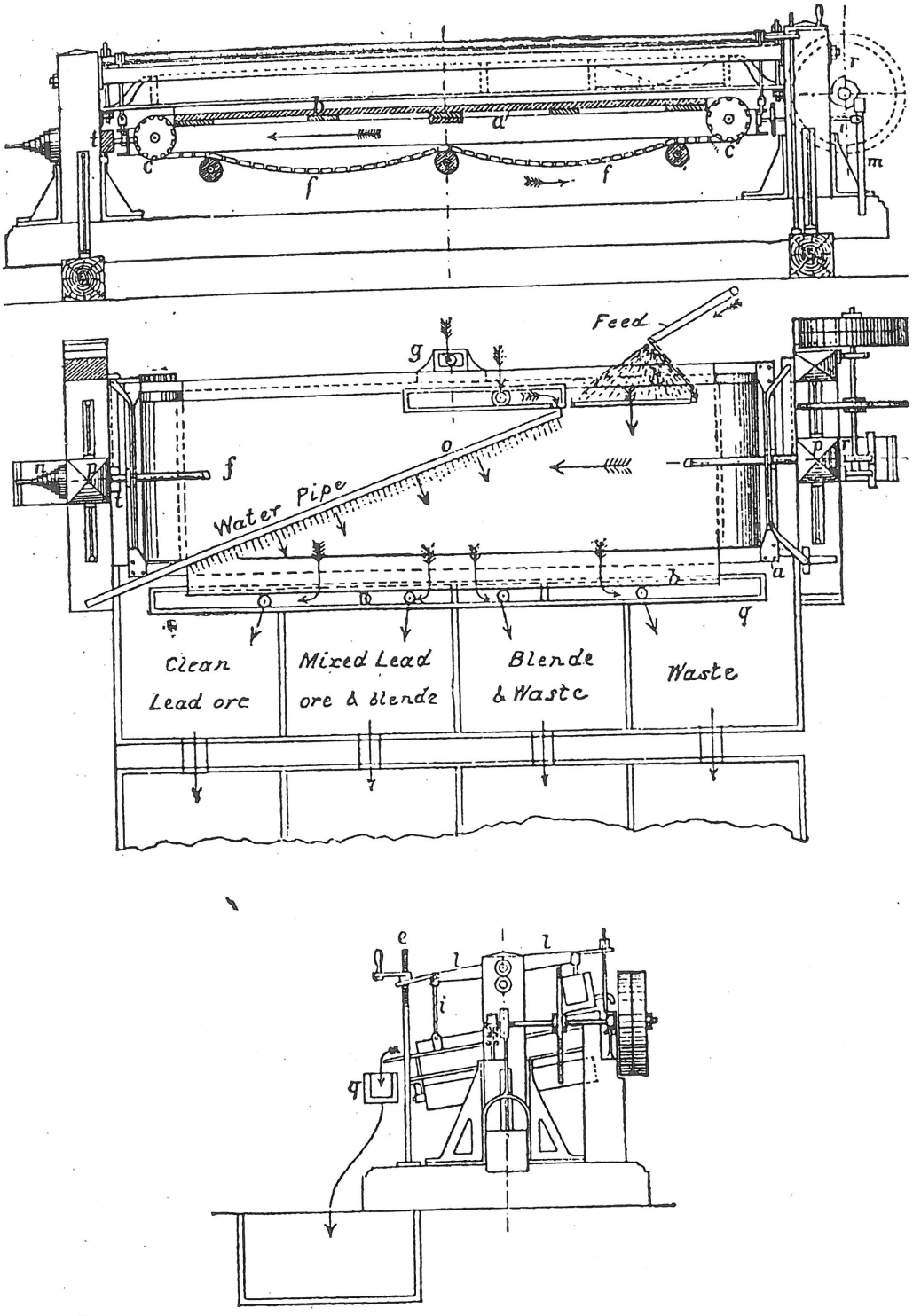
5 The Huntington Mill made use of vertical rollers which were subjected to centrifugal force to crush the ore. They were to be found in the gold mines of Merioneth. From *Ore and Stone Mining* (London, 1910).



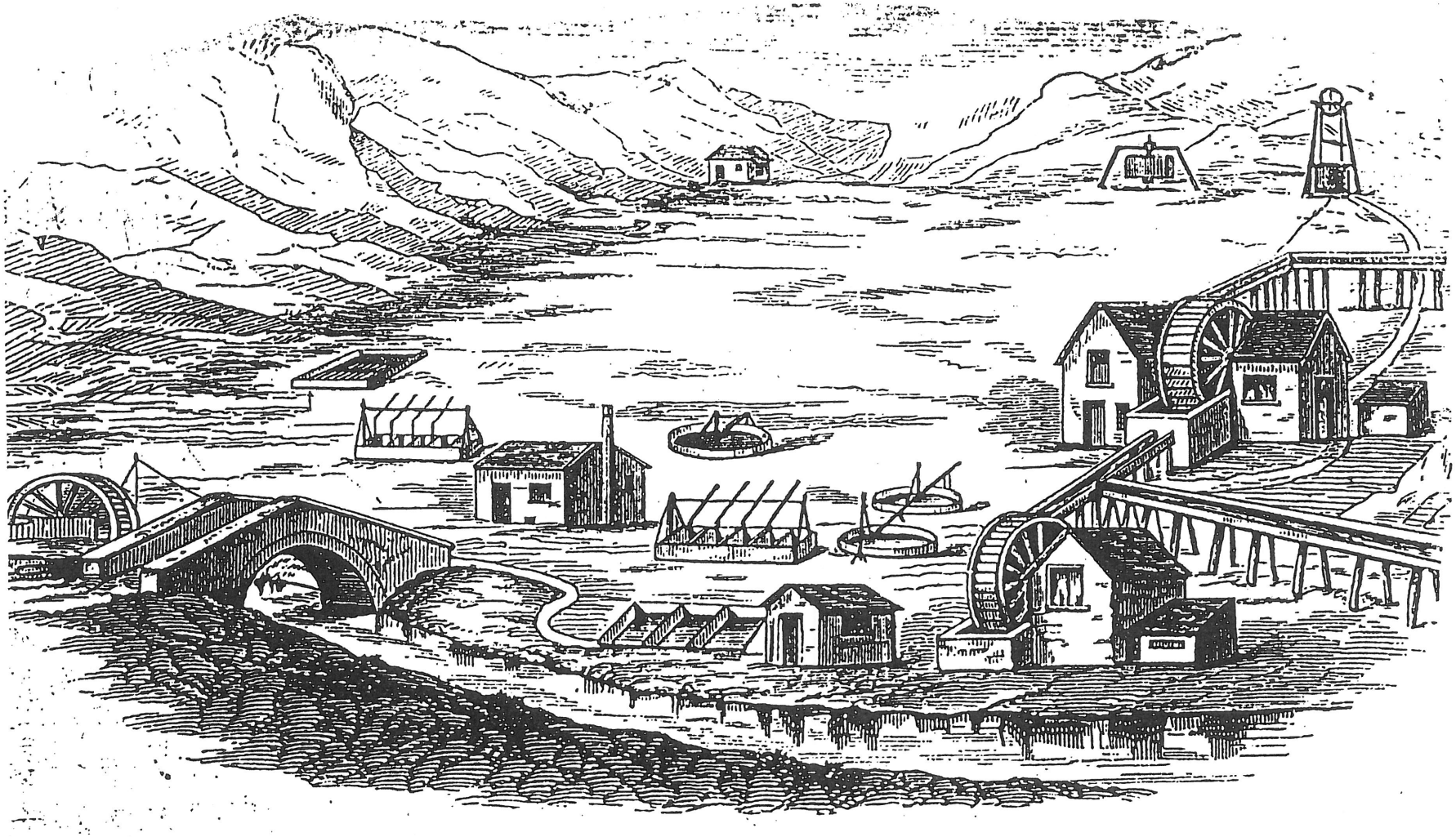
6 A plane table, an inclined wooden device down which pulp flows, leaving a deposit behind. Engraving from *Ore and Stone Mining* (London, 1910).



7 The Perkes patent machine was the ancestor of later devices for processing gold ore, but was never successful. The base of the Perkes machine installed at Red Dragon Mine (PRN: 21066) has recently been conserved by the Welsh Mines Society. Engraving courtesy of David Bick.



8 Travelling belts encompassed several varieties - these included the Fru vanner, the Luhrig concentrator, and the Stein machine, illustrated here, in which the pulp is fed on by a head-board and a constant flow of water passes over the belt, separating the pulp into ore, blende, and waste. From *Ore and Stone Mining* (London, 1910).



9 This engraving of Melin Llyn y Pair Mine (PRN: 21140) was published in *The Mining Journal* Vol.40 (1870) p.371, and shows two crusher houses and hand-operated jiggers and round buddles as well as water-wheels for crushing and pumping, and a timber head frame over a shaft, powered by a horse gin.

6 MANAGEMENT

6.1 Sites of outstanding archaeological significance

The following sites are suggested as being of outstanding archaeological significance:

Trust PRN: 3497

Mynydd Parys Mine windmill: A111A
Mynydd Parys Mine Pearl engine house: A111B
Mynydd Parys Mine Hillside precipitation pits: A111C
Mynydd Parys Mine Great Opencast: A111D

Trust PRN: 4639

Klondyke mill C159

Trust PRN: 1694

Great Orme prehistoric mine (underground) C216

Trust PRN: 21919

Ty Gwyn Mine - tramming adit

Trust PRN: 20688

Hafna mill

Trust PRN: 20535

Drws y Coed Mine - eighteenth century workings, stamp mill.
Drws y Coed village - early nineteenth century miners' community
Drws y Coed Mine mill complex C162

Trust PRN: 21536

Bwlch yr Oen transport system

Trust PRN: 3792

Cwm Bychan early twentieth century aerial ropeway system

Trust PRN: 21578

Cwm Ciprwth Mine (as Gilfach Mine) C170

Trust PRN: 3396

Cwm Erch Mine C193

Trust PRN: 4299

Cefn Coch and Berthlwyd gold-mining complex M119

Trust PRN: 4729

Penrhyn Du Mine - early beam engine house

Trust PRN: 21874

Old Clogau Mine - nineteenth century extraction area and infrastructure.

Trust PRN: 20871

Glasdir Mine - flotation plant base and related processing areas

6.2 Mitigation

Mitigation strategies are suggested in **Appendix 2** to meet the variety of active threats posed to the archaeology of metalliferous mining in Gwynedd.

The most common threat comes from forestry, and while this has prompted the conservation of some sites, it is clear that on the other hand others have been effectively obliterated over the last few years. At Gwydir, mine-sites are increasingly being fenced off in their entirety, and tree-growth threatens small and archaeologically sensitive features, such as hand-dressing sites. Management of commercial woodlands should be carried out in such a way as to minimise damage to sites.

A number of sites are particularly near tourist haunts, and indeed are tourist magnets in themselves. The Gwynedd Archaeological Trust is represented on the Great Orme Country Park Management Group, but the condition of Snowdon group of mines needs to be regularly monitored.

Where a site of whatever grade is threatened with development, the presumption should be that a photographic record at least is necessary, to include all opencasts and underground entries, and all upstanding buildings.

The beam engine houses at Penrhyn Du and at Catherine and Jane Consols call for detailed recording. The former may predate the Pearl engine house at Mynydd Parys, known to have been constructed in 1818-9, and the latter is the only rotative beam engine house identified in Gwynedd.

6.3 Research priorities

Pre-Modern mining remains a little-understood area, and contitutes a priority for future work.

The *Gwynedd Slate Quarries Report 154*, submitted to Cadw in March 1997, outlined the significance of the various barracks and dwellings to be found on or near slate quarry sites. The present report has identified a smaller number but a similar variety of dwellings on or near metalliferous mine sites for workmen and perhaps for their families as well. It is desirable that the work of the previous report be taken forward by the same level of detailed recording for domestic buildings on mine sites in Gwynedd. This would include domestic buildings connected with the Britannia, Hafod y Porth, Drws y Coed, Simdde Dylluan, Cwm Erch, Cwm Dwyfor and Llwyndu mines.

While the histories of a number of the sites suggested as being of outstanding archaeological importance in **6.1** above have been published - Ty Gwyn, Cwm Bychan, Hafna and to some extent Glasdir - a number of others remain obscure. In particular, the various components of the Drws y Coed site have never been fully researched, despite a comprehensive archive in the Caernarfon Records Office and elsewhere. Similarly, the Penrhyn Du beam engine house may date, at least in part, from the late eighteenth century, but further desk-top work is necessary to clarify this, and if possible to establish exactly what sort of machine it contained. It is likely that the Searell papers at UWB will shed light on the Bwlch yr Oen transport system, and the *Mining Journal* may shed light on the evolution of the Old Clogau Mine.

6.4 Conservation

The Welsh Mines Preservation Trust has worked in close co-operation with Cadw on the consolidation of the Pearl engine house at the Mona Mine on Mynydd Parys, as well as on a number of other projects elsewhere in Wales, and has expressed an interest in the consolidation of the Klondyke mill. This is without a doubt the most visually impressive structure connected with metalliferous mining in Gwynedd, a Scheduled Ancient Monument, which has become substantially more dilapidated since the author of the present report first became acquainted with the site thirty years ago. This building must be considered an urgent priority for any future consolidation work.

The Welsh Mines Society is also carrying out conservation work on the Red Dragon Mine near Dinas Mawddwy, the site of attempts to make use of the abortive Perkes machine. This site has been described by David Bick as "the only instance in Mid-Wales where full-scale machinery was erected on site for the purposes of extraction."[77] The base of

[77] D. Bick, *The Old Metal Mines of Mid-Wales 5* (Newent, 1990) p. 19.

the Perkes machine has been consolidated, but the wheelpit is in a parlous condition, with a tree growing out of it. This structure should also be a priority for any conservatuion work.

6.5 Interpretation

Sygun Mine, Gwynfynydd Mine and the Llandudno Prehistoric Mines are open to the public as tourist attractions, and items of historic machinery are on display at the Coed y Brenin Forestry Centre. Low-key interpretation panels have been set up at Hafna, Cyffty and Vale of Conway Mines, and are proposed at Aberllyn. The Snowdonia National Park is understood to be reluctant to sanction interpretative panels at remote sites, even where there has been an element of conservation, such as at Britannia and at Cwm Ciprwth (Gilfach). Footpaths trails are currently under discussion at Mynydd Parys and a similar scheme for Dyffryn Nantlle might in the future include part of Drws y Coed and Simdde Dylluan mines. The proximity of Catherine and Jane Consols to the Ffestiniog Railway makes it a possible candidate for future interpretation.

6.6 Continued consultation

Understanding of the archaeology of Welsh metalliferous mines in general, and those in Gwynedd in particular, has been greatly helped by the work of a number of voluntary organisations, two of which have also become involved in conservation projects. In addition, a number of individuals have made a great contribution to the study of various aspects of the resource, and it is recommended that Cadw, either directly or through the Gwynedd Archaeological Trust, maintain the links that have already been created, and seek to develop others. These are likely to become more important in the near future, as further work is carried out, particularly in the still largely obscure field of pre-Modern mining. A list of voluntary organisations and of indviduals forms **Appendix 1**.

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8 GLOSSARY

The following is a brief explanation of the vocabulary of metal mining as used in the present report. Discussion of mining remains is often bedevilled by an incomplete or conflicting vocabulary, and the problem is compounded in Wales by the use of Welsh-language terms. The intention in the present document has been to use as uniform a vocabulary as possible, taking note of recent discussion on the matter, and to use Welsh terms only where there is no English equivalent (though see **3.6** above). For a full Welsh-language glossary of terms, see Steffan ab Owain, *Geirfa'r Mwynwyr* (Capel Garmon 1988).

Adit: n., a level or near-level entry to an underground working area.
Amalgamation: n., the process by which gold and silver are separated from their ores by their affinity for mercury; in the case of gold by contact, either when it touches the mercury in water or when it is mechanically rubbed against it.
Arrastra: n., a primitive form of **edge-runner**, q.v.
Ball-grinder: n., a device for pulverising ore by bringing it into contact with cast-iron balls in a revolving case.
Berdan pan: n, a device for grinding and amalgamating gold ore, in which two iron balls of unequal size run loose in a rotating bowl.
Bin: n., a receptacle for holding ore.
Bing: n., variant form of **bin**, q.v.
Blende: n., the common ore of zinc.
Britten pan: n., invented by the Rev. Bashley Britten, effectively a mechanical pestle-and-mortar, in which a vertical spindle rotates the pestle; used for grinding and amalgamating gold ore.
Buck: v., the process of breaking ore with a broad flat hammer to reduce it to a coarse powder.
Bucking iron: n., the hammer used to **buck** ore, q.v.
Bucking stone: n., stone on which ore is broken.
Breaker: n., a machine for breaking up ore; these are either *jaw breakers* (see **figure 2**) in which ore is fed into iron or steel jaws, one of which is fixed, the other moved by an eccentric, and thereby crushed, or *gyratory breakers*, in which stone is fed into a conical cup within which a conical centre gyrates.
Buddle: n, a device for washing ore; originally an open box with a sloping bottom, whereby a stream of pulp is fed in at the upper end, forming a deposit decreasing in richness from the upper to the lower end. A *round buddle* (see **figure 3**) is a circular-plan pit with a truncated cone in the centre and a bottom which slopes towards the circumference, into which pulps are fed, depositing the heavier particles near the top and the lighter ones near the edge, the surface of the sediment being kept even by revolving brushes.
Calcination: n., the process of roasting of ore, either in order to remove from it an element which the smelter dislikes or to remove from it a valuable ingredient, or a combination of both. In the case of arsenic, arsenious acid is produced by roasting mispickel and other arsenical ores. Calcining copper sulphides also produces sulphur, as does calcining pyrites. In the case of auriferous ore, calcination removes gold from sulphides and sulpharsenides, in the case of blende it oxidises iron pyrites or marcasite.
Concentration: n., the process of removing extraneous material from the ore prior to smelting, whether mechanically or chemically (see *Elmore concentration plant*).
Concentrator: n., a mechanical device for carrying out part of the process of **concentration** (q.v.), such as the Clarkson-Stanfield dry concentrator, whereby ground ore is spun out from a rotating disc and is caught in a series of annullarly arranged channels, the heaviest particles travelling further.
Copar ledi: n., a woman who cobbed the ore at Mynydd Parys or Drws y Coed (from the English *copper lady*). At Llanberis Mine, the name given to the **stamps**, q.v.
Crusher: n, a machine for the initial crushing of ore, generally between fluted rolls (see **Roll** q.v., and **figure 1**) or in a **Breaker**, q.v.
Dolly-tub: n., a tub in which finely divided ore is stirred and then allowed to settle; used in the final treatment of fine lead ores.
Edge-runner: n., a cylinder turning upon a horizontal axis which is made to revolve around a vertical axis, used in crushing gold and silver ores (see **figure 4**).
Elmore concentration plant: n., a chemical means of concentration, patented by Frank Elmore in 1898, based on the affinity of chalcopyrite for oil. Now commonly used in mining throughout the world, and first employed at Sygun and Glasdir Mines.
Engine-shaft: n., a shaft which houses pumping apparatus.
Flatrods: n., a series of jointed rods connecting a prime-mover to a point at which power is applied. Sometimes referred to as *brammock-rods* or a *rod-engine*.
Flotation: n., a chemical method of separating fine ore-particles from waste, whereby the sulphide particles in the ore have an affinity for oil not shared by waste particles.
Frue Vanner: n., a variety of **Travelling belt**, q.v., comprising an endless belt of india-rubber cloth which can be agitated from side to side, onto which pulp is fed, and particles divided into rich and poor.

Galena: n., lead sulphide, the common ore of lead.
Gangue: n., ore matrix, commonly quartz, calcite orcountry rock.
Gin: n., from the word "engine"; a device operated by a horse or horses (and commonly called a horse-gin) walking on a circular track and either turning a haulage drum on a vertical axis for raising a kibble from a shaft or opencast or more rarely operating a pump within the shaft by means of rods. The former is known as a **whim** (q.v.) though this word can mean any haulage engine, or *horse-whim*; archaeologically it is rarely possible to distinguish between the purposes of a circular horse-track, and for this reason the all-embracing word gin is preferred.
Halvans: n., poorer ore; an area of ore-processing.
Huntington mill: n., a machine in which ore is ground by being placed in a revolving pan equipped with vertical rollers which are subjected to centrifugal force against the annular lining and crush the ore (see **figure 5**)
Jigger: n., a device for concentrating particles, a sieve charged with crushed ore and then moved up and down in water, which allows the heavier particles to settle at the bottom. A Harz jigger has several sieves in the one device.
Kibble: n., bucket for raising ore up a shaft.
Ore: n., defined by the Institution of Mining and Metallurgy in 1955 as "a solid naturally occurring mineral aggregate of economic interest from which one or more valuable constituents may recovered by treatment." *Undressed ore* is the ore as it comes from the mine, and *concentrate* is the ore after extraneous material has been removed prior to smelting.
Ore-chute: n., an underground passage in which mineral can be allowed to fall to the level below.
Ore-slide: n., a timber structure on which ore is transported on the surface by being slid downhill.
Percussive table: n., an inclined rectangular platform suspended by its corners and agitated back and forth, onto which ore-rich water is fed, and heavier and lighter particles separated by their different weight. *Rittinger tables* have the characteristic of being agitated in a direction at right angles to the flow of pulp, and *Wilfley tables* are narrower at their lower end, and agitated in such a way that it moves slowly at first slowly and then quickly on each stroke.
Perkes machine: n., a crushing and amalgamating machine, invented by Samuel Perkes, in which conical iron rollers crushed the ore inside a drum-shaped container made of cast-iron, and mercury was used for amalgamation (see **figure 7**).
Plane table: n., inclined wooden table down which pulp flows, leaving a deposit behind (see **figure 6**).
Precipitation: n., a method of extracting copper from water whereby copper-impregnated water is allowed to react with iron in open pits. Also known as *cementation*.
Pulp: n., a stream of fine ore suspended in water.
Reverberatory furnace: n., a furnace in which the flame plays into the space containing the charge.
Rittinger table: n., see **Percussive table**.
Roll: n., a device for crushing ore, consisting of two rolls, fluted, toothed or smooth, geared to one another and held together by a weight suspended from a projecting arm. An improved form known as the Cornish roll was introduced in 1885.
Sieve: n., a hand sieve, as in Merionethshire manganese mine, or a mechanical sieve, either a flat and oscillating sieve or a revolving cylindrical, conical, pyramidal or spiral sieve (see **Trommel**), used to grade the crushed ore.
Slime: n., material crushed very finely and suspended in water.
Sphalerite: n., zinc sulphide, zinc blende, blende, blackjack.
Stamps: n., vertical columns, originally of wood shod with iron, raised by cams to crush ore. California stamps were all metal.
Stope: n., the working chamber excavated up from the adit along the lode, which may reach daylight. Hence *stoping*, the process by which chambers are opened to a higher level.
Tailings: n., the waste from ore-dressing or -processing.
Tom and Jerry: n., a water-bucket engine, whereby a bucket on hinged arms is filled with water at the top of a stroke until its weight brings it down to a point where it is emptied, then is drawn back up by a counterweight, and the process is repeated; also known as a *flop-jack engine*. Generally employed to operate a pump.
Travelling belt: n., a device whereby pulp is fed onto a belt over which a flow of water passes, separating the pulp into ore, blende and waste (see **figure 8**).
Trommel: n., a revolving sieve.
Washing: v., the process of removal of earthy impurities from ore.
Water-pressure engine: n., a prime-mover in which the piston in a cylinder is operated by admitting water under pressure to the cylinder.
Whim: n., a haulage drum on a vertical axis for a kibble raising ore from an opencast or a shaft, operated by a horse or a mechanical prime-mover. See also **Gin**.
Windlass: n., a haulage drum on a horizontal axis, operated manually.
Winze: n., an underground shaft excavated downwards.
Wilfley table: n., see **Percussive table.**

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9.1.3 LLRO

Abandoned Mines Plans

9.1.4 CRO

Vaynol
Glynllifon
Poole
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9.1.5 DRO

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Williams-Jones K: "Llywelyn's Charter to Cymer Abbey in 1209" *JMHRS* 3 1 (1957) pp. 45-78.

9.5 Visual material

9.5.1 British Library

Add Ms 42037, fol. 39 - drawings of Llandudno Old Mine.

9.5.2 Lady Lever Art Gallery, Port Sunlight

John Smith, *Llanberis Mine* (LP30).

9.6 Internet

Mining History Network (Dr Roger Burt):
http://info.exeter.ac.uk/~RBurt/MinHistNet/welcome.html

British Library catalogue database:
http://opac97.bl.uk.

Appendix 1:

Individuals and voluntary organisations connected with the study and conservation of metalliferous mining in North-west Wales

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