

GWYNEDD SLATE QUARRIES
AN ARCHAEOLOGICAL SURVEY

1994-5

REPORT NO. 154

YMDDIRIEDOLAETH ARCHAEOLEGOL GWYNEDD
GWYNEDD ARCHAEOLOGICAL TRUST

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prepared for Cadw: Welsh Historic Monuments
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Abbreviations.

The following abbreviations are standard:

CRO: Caernarfon Record Office, Victoria Dock, Caernarfon.

DRO: Dolgellau Record Office, Council Offices, Dolgellau.

GAS: Gwynedd Archives Service.

HRO: Hawarden Record Office, The Old Rectory, Hawarden, Deesside, Clwyd.

NLW: National Library of Wales, Aberystwyth.

PRO: Public Record Office, Chancery Lane, Kew, London.

UWB: University of Wales, Bangor.

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Measurements.

Practically all the machinery and structures examined in the course of this survey were designed and built according to imperial measurements. The only major exception appears to be the Bruce Peebles electrical machinery discovered in some quarries. Therefore, all measurements are given in feet and inches.

1.0 INTRODUCTION

This project has been funded by Cadw: Welsh Historic Monuments, and builds on the work carried out for the Cadw-funded Gwynedd Quarrying Landscapes project in 1993/4. That project identified twenty-five quarrying landscapes, which contained the most significant remains of slate quarrying in Gwynedd. This project has concentrated on identifying the archaeological resource of the slate quarrying industry in Gwynedd, and identifying from that resource those features considered to be of national importance.

2.0 AIMS

The aims of this project were to examine the documentary resource relating to the Gwynedd slate quarries, and to follow this with an extensive survey of quarries, identifying the condition of the remains and the level of threat to those remains. The quarries chosen for survey were to be those identified during 1993/4 as containing the more significant archaeological remains. A list was then to be drawn up of those features considered to be of national importance.

3.0 METHODOLOGY

3.1 General

The specific aims of the project (as outlined in 2.0 above) allowed a structured approach to be adopted which took the following form:

- 1) An archive and literature search, accompanied by the creation of a bibliography;
- 2) Fieldwork;
- 3) Entry of the fieldwork data onto a computerised database;
- 3) Analysis of the fieldwork data and bibliographic data;
- 4) Incorporation of the results of the project into a final report.

Much of the work undertaken during 1994/5 built on the work carried out for the Slate Quarrying Landscapes project undertaken in 1993/4. During that project, all the known slate quarries in Gwynedd were classified on a scale of 1 to 5 depending on the quantity and quality of archaeological remains on the site. The five classifications were defined as follows:

1. Sites or remains of international archaeological importance.

A nearly complete range of quarry buildings, representing all stages of production. The presence of machinery and individual features of merit was a strong factor in placing sites in this category.

2. Sites or remains of national (Welsh) archaeological importance.

A substantial range of quarry buildings, structures and some machinery, but with few or no features of special merit.

3. Sites or remains of regional (Gwynedd) archaeological importance.

A quarry with associated structures, of which only foundations need to remain.

4. Sites or remains of local archaeological importance.

Nearly all quarries which have worked commercially and which do not fall into Categories 1 - 3 would come into this group.

5. Sites or remains too ruined or of too little significance to fall into Categories 1 - 4.
Former sites of quarries or very small trials of which only a pit and associated tip remain.

In addition, appendix 3 of the resulting report (hereafter referred to as **Report No. 129**) discussed the criteria for establishing monument value. However, experience during the current year's work suggested that certain of the definitions as proposed in that appendix required changing if they were to be of practical benefit. The way in which each of the criteria was finally used is described below.

3.2 Criterion for scheduling ancient monuments

The eight criteria for assessing the national importance of monuments as defined by the Secretary of State for Wales in PPG 16 are:

- (a) Period
- (b) Rarity
- (c) Documentation
- (d) Group value
- (e) Survival/condition
- (f) Fragility/vulnerability
- (g) Diversity
- (h) Potential

In addition it was intended to consider ways in which the following criteria might also be incorporated:

- (i) Amenity value
- (j) Visual amenity.

Consideration of a monument as a candidate for scheduling was based on an overall evaluation of all the relevant criteria (defined individually below) and supported by a professional interpretation.

a. Period

This criterion was only used if the date of the structure under consideration was known to be a particularly early or late example of that structure type. The criterion was not applied in the field, but after all the fieldwork had been completed. This criterion was only applied if the date of the structure was thought to raise its archaeological significance, in which case the entry is marked with a "Y" in the database.

b. Rarity

This criterion was applied after completion of all the fieldwork, when those structures discovered to be rare were marked as such with a "Y" in the database. No entry in this field means the structure is typical of its type, with a number of examples surviving.

c. Documentation

This criterion could not be applied to individual structures, but instead was applied to the quarry as a whole for those quarries which were visited. This criterion appears on the printouts as 1, 2, 3, with 1 being the preferred state in each case.

This criterion was rated as follows:

Archival:

LOW (3) - scattered references, local and central government documentation, OS maps.

MEDIUM (2) - some surviving quarry company archival documents, some reference in contemporary technical press.

HIGH (1) - quarry company minute books, sales ledgers, official plans, detailed accounts in contemporary technical press.

Archaeological:

LOW (3) - limited description and sketch survey only

MEDIUM (2) - some measured survey, photographic record, ground plans.

HIGH (1) - description, full measured survey, photographic record, published report.

d. Group value

This criterion was used to describe the archaeological value of the inter-relationship of features. The entry has a "Y" if that feature added archaeological value to another feature, and if the result of the relationship was greater than the value attributed to the two features independently.

e. Survival/condition

These two criteria were applied separately and were completed in the field. Survival was used to indicate how much survives of what is originally thought to have existed, whereas condition was used to indicate the physical condition of the site. Both were scored High, Medium, Low which appear on the printouts as 1, 2, 3, with 1 being the preferred state in each case.

f. Fragility/vulnerability

These two criteria were applied separately and were completed in the field. Fragility was used to describe the state of, and probability of, deterioration from natural erosion and weathering, whereas vulnerability was used to describe the likelihood of damage from human agency. Both were scored high/medium/low, which appear on the database as 1, 2, 3 with 1 in both instances being the preferred state.

g. Diversity

This criterion was applied on a quarry basis, by scoring each quarry high/medium/low, which appears on the printouts as 1, 2, 3, with 1 being the preferred state in each case, according to the following definitions:

LOW (3) - fewer than the average number of expected component features present for the particular class of site under consideration.

MEDIUM (2) - average number of expected component features present for the particular class of type under consideration.

HIGH (1) - greater than the average number of expected component features present for the particular class of site under consideration.

h. Potential

This criterion appears with a "Y" in the field if there appears to be sufficient archaeological potential to raise the value of the feature.

Application of further criteria

Two further criteria were considered:

i. Amenity Value

This criterion was applied following the completion of all the fieldwork, and relates to the quarry as a whole. A quarry was therefore scored 1, 2, 3, with 1 being the preferred state in each case, according to the site's suitability for amenity use.

j. Visual Amenity

This criterion was applied in the same way as amenity value, that is to the quarry as a single site. The quarry would be scored 1, 2, 3, with 1 being the preferred state in each case, if the value of the site was thought to be raised by its visual aspect either from afar, or because of the visual attractiveness of the features within.

3.3 Criteria for listing historic buildings

The listing of historic buildings is carried out by the Secretary of State for Wales, under the Planning (Listed Buildings and Conservation Areas) Act 1990. The definition of a building suitable for listing is given as: Any building which is of special architectural or historic interest, which includes "any structure or erection, and any part of a building, structure or erection but does not include any plant or machinery comprised in a building". However section 1(5) of the Act treats as part of a building: a) any object or structure fixed to the building; and b) any object or structure within the curtilage of the building which, although not fixed to the building forms part of the land and has done so since before 1 July 1948.

The principles of selection are set out in Appendix 1 of DOE Circular 8/87, which until the adoption of PPG 15 by the Welsh Office forms the principal guidelines for listing, and are as follows:

- a) All buildings built before 1700 that survive in anything like their original condition.
- b) Most buildings of 1700 to 1840 are listed, though selection is necessary.
- c) Buildings dating from between 1840 and 1914 are only listed if of definite quality and character, and the selection is designed to include the principal works of the principal architects.
- d) Selected buildings dating from between 1914 and 1939 of high quality are listed.

When buildings are selected for listing they are placed into one of three grades:

Grade I: Buildings of exceptional interest.

Grade II*: Particularly important buildings of more than special interest.

Grade II: Buildings of special interest, which warrant every effort being made to preserve them.

Less than 10% of slate quarry features looked at during the course of this survey pre-date 1840, and those that were observed did not appear suitable for listing. However, various structures of post-1840 date were noted that were believed to be of national importance, but were still in use by the quarry, so were not suitable for scheduling. These features are noted in Appendix 2. The fieldwork methodology used throughout this project was designed for applying scheduling criteria, as discussed in 3.2 above, and features were only considered for listing if they met the scheduling criteria, but could be recommended for scheduling because they were still in use.

3.4 Archive and literature search

This work was undertaken by utilising the resources of the UWB library, the UWB archives, and the Dolgellau and Caernarfon branches of the Gwynedd archives. It was not possible to collect full references for all sites, but the major relevant manuscript collections were noted, and those collections which contained substantial references to slate quarrying were also noted. In addition, collections from the National Library of Wales and the Public Record Office have been included although they were not visited for the direct purposes of this study. See **4.0 Documentary Resource** for a discussion of the sources used.

3.5 Fieldwork: Recording technique

It was decided to record all features within a quarry which were assumed to have been built before 1939 and which survive above ground. It was not possible to consider archaeological remains underground, although both machinery and structures are known to exist there, often in better condition than those above ground. Only those features owned by and directly related to a quarry were recorded; other related features such as independent mills, independent railways etc were not included. Exit railways were included up to the point they left the obvious confines of the quarry.

The on-site recording took the form of structure identification, structure location, and scoring for survival, condition, fragility and vulnerability. Notes were made for those structures where amplification was necessary. All principal features were photographed in black and white film for archival purposes, and selected views were taken in colour slide film.

An A4 map (or series of maps) at a scale of either 1:2500 or 1:10000 was prepared for all quarries, on which the location of each feature was identified with an unique number. This feature number was then used on a simple recording form which was designed to allow for the rapid recording of the necessary information as described above. Although all sites were walked over, the size of certain quarries means that some features may have been missed, and in the case of Dinorwic, the size of the quarry allowed only selected parts to be visited.

3.6 Sampling technique

The project was designed at the outset with the assumption that a justified (as opposed to random) sampling technique would be used to list those quarries to be visited. The justification for visiting came principally from the ranked list of quarries in Report No. 129, which were ranked on a scale of 1 to 5

according to the quantity and quality of the archaeology on the site. However, comments received from consultees who had been sent a copy of the report, and personal knowledge of the project officers was also taken into account. The intention was to visit all those quarries included within the identified slate quarrying landscapes, plus others known to have remains of particular significance.

Twenty five quarrying landscapes had been identified, containing seventy quarries. All twenty-five areas have been subsequently visited, although eleven of the seventy quarries were not visited,¹ because, although belonging to a landscape of significance, it was felt they did not contain archaeological remains of sufficient quality to warrant further investigation.²

The initial report identified 464 quarries, although following revision twenty-one were removed which were either duplicates or just outside the county boundary. This left 443, divided into five classes, of which 106 were visited.

CLASS	NO. AT START	NO. VISITED	NO. AFTER REVISION
1	14	14	14
2	56	44	52
3	87	33	89
4	125	6	123
5	182	9	165
TOTAL	464	106	443

A number of the quarries visited had their ranking changed as a result of the visit:

20016	Singrig	3 to 4
20019	Coed Madoc	5 to 4
20022	Cloddfa'r Coed	5 to 4
20027	Cornwall	3 to 4
20034	Cilgwyn	5 to 3
20062	Tan y Bwlch	4 to 3
20075	Glynrhonwy Lower	5 to 4
20097	Hendre	2 to 3
20101	Dulyn	5 to 4
20107	Hafoty	5 to 3
20313	Rhiwbach	2 to 1
20380	Penrhynwyn	2 to 3
20428	Cwm Ebol	2 to 3
20472	Abercorris	2 to 3
20489	Ratgoed	1 to 2

3.7 Post fieldwork analysis

¹ PRN 20074, 20066, 20175, 20177, 20180, 20286, 20290, 20291, 20308, 20309, 20310.

² It was only possible to visit the Coed y Parc mills area of the Penrhyn quarry (20061) and a part of the Dinorwic quarry (20091).

The fieldwork data was entered into a computerised database, related to the principal quarry database by PRN. The additional criteria were then completed for each feature or each quarry where applicable. Analysis was then undertaken by type and a combined score to produce a ranked list of features. Professional judgement was then used to select those features thought to be of national importance, and which therefore may be suitable for scheduling or listing. From the 105 quarries visited, 35 are thought to contain some 442 features of national importance. These features are described by type in section 5.0 below, and by quarry in Appendix II. Appendix III contains a complete list of quarries visited and features recorded, accompanied by a map at a scale of 1:5000 (some of the very small quarries with few features do not have a map) showing each of the features identified.

4.0 DOCUMENTARY RESOURCE

The documentary resource was divided up as follows:

- 1.) **Article in:**
 - a) journal
 - b.) monograph
- 2.) **Manuscript collection**
- 3.) **Map**
- 4.) **Monograph**
- 5.) **Newspaper**
- 6.) **Official record**
- 7.) **Photograph**
- 8.) **Pictorial reference**
- 9.) **Projected/video material**
- 10.) **Thesis**
- 11.) **Unpublished work**
- 12.) **Verbal communication**

It very quickly became clear that the documentary resource for the Gwynedd slate industry was vast, even by the standards of equivalent British industries. Not only do the internal records of many of the major and middle-rank quarries survive (and others are still coming to light) but the industry itself has attracted consistent interest from local people and visitors, which has expressed itself in varied ways - eisteddfod essays, for instance are a useful source, and some of those published in the nineteenth century, particularly in the Ffestiniog region, are invaluable. More recently, from the second world war onwards, outside interest has focused on the quarry transport systems, which has led a number of writers to consider the archaeology of other aspects of the industry. The outstanding work here remains the pioneering *Rhosydd Slate Quarry*, by Dr Michael Lewis and John Denton, published by The Cottage Press, Shrewsbury, in 1974. However, Jean Lindsay's *A History of the North Wales Slate Industry* (David and Charles, 1974) and Alun Richards' *Gazeteer of the Welsh Slate Industry* (Gwasg Carreg Gwalch, 1992) remain the only overall studies. Comparatively little interest has been shown by academic institutions, though a number of theses connected with the slate industry have been submitted for degrees at the University of Wales, Bangor, and elsewhere, and Professor R. Merfyn Jones' *The North Wales Quarrymen, 1874-1922*, though its subject is the historical sociology of the industry, considers the quarrymen's work-patterns and the changes in organisation which led to the major conflicts within the quarries.

However, in all cases, the survival of records is a matter of chance, and published works concentrate only on areas of individual interest, leaving considerable gaps in the resource.

The first type of source consulted in the survey, wherever it existed, was an internal quarry archive. Those relating to Penrhyn, Dinorwic, Dorothea, Pen yr Orsedd, Croesor, Oakeley and Llechwedd form a remarkably comprehensive record,³ including plans, paybooks, accounts of slate production from individual galleries and levels, etc. These, however, are mostly large-scale quarries with histories of more or less continuous working. Where quarries were worked by a series of partnerships or limited companies, internal records are less likely to survive, or not to survive for the whole period of the quarries' history. In the case of Bryn Hafod y Wern, near Bethesda, the quarry's account books survive from 1847 to 1860, and the minute books from 1845 to 1857, but no documentation is known to survive from the last phase of operations, which began in 1872.⁴ Similarly in the case of Rhiwbach, near Blaenau Ffestiniog; the quarry operated from the eighteenth century to the 1950s, and whilst the sales records survive from 1858 to 1878 and other records for the period 1896 to 1913, there are long gaps in the site's history for which the quarry's own archive is partly or entirely lost.⁵

To some extent these gaps can be filled with official records. Though the informal partnerships of quarrymen who often took on a site in the early nineteenth century (an arrangement which was to enjoy a revival after 1929, and which survives to some extent to this day) are often undocumented, limited companies set up under the Limited Liability Acts have left their records in the form of the Board of Trade archive in the Public Record Office, Kew (BT41, BT31). These contain a list of subscribers, shareholders, and company officers, and give the date of registration and the address of the registered office. One in five of the annual list of shareholdings is preserved, enabling a partial reconstruction of transfers. They occasionally contain parts of a quarry's account for a particular period, which can be useful for dating a particular construction project.⁶ An abstract of those that relate to Gwynedd slate quarries (as well as of other mines and quarries within the county) has been deposited with the Caernarfon, Dolgellau and Llangefni archives.⁷

Other papers preserved in the Public Record Office, though in this case the Chancery Lane branch, are those of the Crown Estates, preserved as LRRO. These preserve lease documents relating to slate workings on crown lands or where the crown reserved the mineral rights, which included Manod, all the quarries in the Moel Tryfan area, and Cilgwyn. These are in each case accompanied by a plan, which occasionally shows the quarry in great detail. The Crown Estates records also preserve copies of the out-letters which occasionally give explanations as to why rents have been reduced, for reasons such as the tenant's expenditure on new machinery.⁸ Rarely does correspondence survive in its entirety; an exception seems to be the letters to and from the Office of Woods, Forests and Land Revenue concerning the tiny trials at Dulyn (20101), which chart the commercial optimism (or possibly speculative talents) which led a group of local farmers and nonconformist clergymen to undertake operations in this remote and unpromising spot.⁹

The records of locally-based landlords are in many cases comprehensive, and generally preserve the take-notes (right to prospect), leases and rentals. In the case of Penrhyn and Dinorwic, the quarry administration formed part of the estate as a whole, and they were worked directly by their landlords.

The other major estates, Gwydir, Newborough of Glynllifon, Baron Hill, Mostyn, Peniarth, leased out their quarries and for the most part preserve some records. Mostyn seems to have least; probably the

³ CRO Penrhyn Quarry, Penrhyn Quarry Additional, Dinorwic Quarry, Dorothea Quarry, Pen yr Orsedd Quarry, Pen yr Orsedd Additional, DRO Oakeley Quarry, Croesor Quarry, Llechwedd Quarry, greaves collection, NLW Croesor.

⁴ CRO XM/495/1-17.

⁵ UWB Rhiwbach, NLW Rhiwbach 18374-90.

⁶ E.g. BT31/63/239, Caernarvonshire Slate Company, account of construction of railway from the quarry to the Nantlle Railway.

⁷ Gwynedd Archives Service, Jeremy Wilkinson list of Mines and Quarries.

⁸ PRO Chancery Lane CRES15

⁹ CRES2/1574

quarry leases and administration were handled by a different part of the estate office. For whatever reason, nothing survives in the Mostyn papers at U.W.B. about their South Snowdon. Some information survives in Peniarth deeds at N.L.W. about Cwm Machno, in the form of lease documents, but no rentals. The Cyfronydd estate collection at N.L.W. contains records of the Aberllefenni slate quarry.

The Baron Hill papers at U.W.B. include leases and rentals, including several of Cwm Eigiau quarry, but the most comprehensive sets of estate records are Gwydir, preserved at Grimsthorpe Castle and at the Leicester County Record Office, and Newborough (Glynllifon), preserved at the Caernarfon Record Office. The Gwydir papers include documents relating to the quarries on their estate (those in Trefriw/Llanthychwyn, Dyffryn Lledr and near Betws y Coed) from 1788 (though they are scanty until 1810) to the sales of 1894 to 1896 - though little enough survives to illustrate the later history of Ty'n y Bryn, Rhiwgoch, Bwlch Cynnud and Chwarel Ddu, which carried on working well into the twentieth century.

The Newborough estate included the Glynrhonwy quarries east of Llanberis, Cedryn in Dyffryn Conwy and Lord (swallowed up in Votty and Bowydd) at Blaenau Ffestiniog. The Glynllifon collection at the N.L.W. has been largely transferred to the Caernarfon Record Office, where it has been joined by a remarkable cache of letters, still in the process of being catalogued, comprising every letter received by the second and third Lord Newborough from their schooldays onwards. Many of these are from the agents of their outlying estates with details of how the quarries were functioning mixed in with other matters to do with farming and shooting. In particular, correspondence from William Elias of the Abbey and Ardda (Dolgarrog), a compulsive letter-writer, provides a detailed source for Cedryn quarry and its neighbour, Cwm Eigiau. In addition, the fact that Lord Newborough was related by marriage to Jeffreys Parry de Winton, the Caernarfon engineer, means that a great deal of information about the slate quarrying industry of Gwynedd survives in this enormous archive - for instance, a letter from de Winton declining an invitation to lunch as he is trying out a new locomotive at one of the Glynllifon quarries.

The records of local law firms - Yale and Hardcastle, Breese Jones Casson in C.R.O., Carter Vincent and Porth yr Aur in U.W.B., Machynlleth Deeds in N.L.W. - contain information about a number of quarries; Porth yr Aur, in particular, contains a great deal of information about the early days of Cefn Du, Dinorwic and Cilgwyn.

Another major resource, common to all quarries after a certain date, is the official 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. Photocopies of these have been deposited in the three Gwynedd Record Offices. Published accident reports are a useful source, but there are no copies nearer Gwynedd than the Manchester Central Reference Library.

Maps and plans are frequently found with leases, sometimes with take-notes, and are frequently found amongst quarry engineering records or as casual survivors in the County archive's general collection. The Health and Safety Executive's collection of mine and quarry plans at Bootle has recently been transferred to all the County Record Offices and includes a number of chance survivals from before the period of the statutory requirement to deposit plans of underground workings. The ordnance survey maps form an indispensable tool for the analysis of the archaeological resource, and the old county series 25" was extensively used in the preparation of the report. Unlike the present-day equivalent, these show quarry features in great detail, including all but the most temporary lengths of railway, which frequently gives a clue to the purpose and function of now vanished or degraded structures. It was, for instance, frequently possible to tell from a map whether an incline had been a counterbalance or a water-balance by the arrangement of rails and by the presence or absence of a water-channel to the summit.

The original 1" survey of 1839 to 1841, though not particularly detailed, nevertheless shows the site of early workings, and marks railways and inclines, as to some extent does the 1 1/2 miles survey of 1819 to 1821, of which a negative photocopy is available in the County Record Offices.

This largely exhausts the list of official records of one sort or another, but leaves out of the picture the considerable corpus of unofficial and informal records, often of an apparently ephemeral nature, which can amplify the resource, or which in some cases is all that survives. These take various forms.

One of the most important is *The Mining Journal*, of which copies exist at the N.L.W. and H.R.O. References to the Gwynedd slate industry abound, in the form of promotions, share-offers and technical descriptions, though it is clear that these need to be treated with some caution. *The Mining Journal* itself seems to have been aware of the very speculative nature of many of the undertakings, and was prepared to publicise them; it is possible that some sort of *quid pro quo* operated, and any reference needs to be regarded as effectively a form of publicity rather than a statement of fact. The other technical journals, *Engineering* and *The Engineer*, are more objective. Copies are held in the Manchester Central Reference Library. The *Annales des Mines* also contains some references to the Ffestiniog Quarries. A run is held by the University Library, Cambridge.

The considerable interest in local history which the nineteenth century *eisteddfodau* fostered, led to the preservation, and in some cases the publication, of much detail that would otherwise have been lost. Writers such as Jonathan Davies, Owen Morris, William Jones Ffestinifab, G.J. Williams, Owain Gethin Jones and Hugh Derfel Hughes are invaluable sources for quarry history, even though they can be very weak on dates.¹⁰ Chapel histories, or histories of a particular connection, can often give details which are otherwise lost, such as Pererin Llesg's *Hanes y Pregethwyr godwyd ym Mhenmachno*,¹¹ which describes the lives of a number of clergymen in their original calling as quarrymen or stewards before they entered the ministry. The emphasis on anecdotal material in these sources can be enlightening, as they describe men working a particular machine or in a particular department of a quarry.¹²

This tradition remains a very lively one in the slate districts to this day, and increasingly takes the form not only of essay-writing but also of practical industrial archaeology, recording, measured surveys, and the taping of reminiscences by former quarrymen. In this connection, it is only fitting to point to the excellent work being carried out by the *Fforwm* at Plas Tan y Bwlch, which has led to the publication of a history of Blaen y Cwm quarry¹³ and to a manuscript history of Rhiwbach.

The work of the *Fforwm* illustrates the way in which amateur recording can be at least of the same standard as the work of professional archaeologists, and that the tradition of *hanes lleol* can be taken to a high academic level is also demonstrated by the work of Gwynfor Pierce Jones of Pen y Groes, whose M.A. (Wales) degree for a thesis on the history of Dorothea Quarry was awarded in 1980, and who is currently working on a doctoral dissertation on the subject of the Nantlle slate industry as a whole. The work of the slate quarry study courses that have taken place at Plas Tan y Bwlch under the direction of Merfyn Williams, now of the Campaign for the Protection of Rural Wales and Dr Michael Lewis of the University of Hull, has led to the detailed recording of the major quarries on the Gwydir estate. The surveys are kept at Plas Tan y Bwlch under the care of Peter Crew, Snowdonia National Park Archaeologist.

¹⁰ Owen Morris, *Portmadoc and its Resources* (Blaenau Ffestiniog, 1856), Hugh Derfel Hughes, *Hynafiaethau Llandegai a Llanllechid* (Bethesda, 1866) Jonathan Davies, *Hanes Chwarelau Ffestiniog* (lls., 1875), W. Jones, *Hanes Plwyf Ffestiniog* (1879), Owain Gethin Jones, *Gweithiau Gethin* (Llanrwst, 1881)

¹¹ *Hanes pregethwyr godwyd ym Mhenmachno yn ystod y pedwar ugain mlynedd diweddar, gyda phob enwad* (Llanrwst, John Lloyd Roberts, ?1913)

¹² The anonymous essay "Hanes Chwareli Machno", which won first prize in the Penmachno Wesleyan Young Men's eisteddfod of 1912 is an excellent example of this genre. The essay itself was discovered in a chapel safe in Llandudno Junction in 1989 by Mr Gwynfor Jones, and it constitutes one of the main sources for the history of Cwm Machno quarry, as well as amplifying the record on Blaen y Cwm, Cwt y Bugail and Bwlch y Slaters.

¹³ G.R. Jones (gol.) *Chwarel Blaenycwm a elwir hefyd yn Benffridd* (1991)

The involvement of people from outside the area, whose interest initially was often aroused by the railway preservation movement, has considerably amplified understanding of the industry. The bibliographical references have been given in the interim report, but mention should also be made to the work of Jeremy Wilkinson of Wilmslow, who has built up a database of archive references to extractive industries in the County generally, which the Gwynedd Archaeological Trust was able to consult in the course of the survey. Graham Isherwood and Eric Foulkes are currently researching major projects on Oakeley and Penrhyn respectively, which they hope to publish at some stage.

Visual material is abundant, but of varying usefulness. The resource begins with the artists who travelled to Gwynedd in search of the sublime and the picturesque once the Revolutionary and Napoleonic wars cut off the continent. It is now known that the aquatint by de Louthembourg *The Slate Mine* in the N.L.W., which appears as the cover illustration to *Chwarelwyr Cyntaf Blaenau Ffestiniog/Pioneers of Ffestiniog Slate* (Plas Tan y Bwlch, 1989) is of Rydal Water in the Lake District,¹⁴ and it is unfortunate that the many artists who depicted Dolbadarn castle should have neglected Dinorwic quarry to the north. Penrhyn, with its extensive gallery system and tourist facilities nearby at Bangor and Capel Curig, fared better, but the views rarely add to an understanding of the archaeology of the industry. An exception is the engraving published in *The European Magazine* in 1808, which shows the gallery system still in course of development, and wooden railways.¹⁵ Some of the engravings in nineteenth-century technical journals are of considerable merit in explaining how particular machines functioned.

Photography makes a limited impact from the 1870s, with the work of John Thomas of the Cambrian gallery, Liverpool, whose work is preserved in the N.L.W., a collection which shows Cwm Machno, Diffwys (Casson), Braich Goch and possibly Rhiwbach. Griffith Jones of Port Dinorwic took a large number of photographs of Dinorwic around the turn of the century, preserved in the C.R.O. in glass negative form, and picture postcards begin to be produced locally from around the same time. The Gwynedd Archive Service's collection includes over 2,000 photographs of slate quarries, but the main areas are very heavily represented, and hardly any were found showing quarries outside the Bethesda, Llanberis, Nantlle and Ffestiniog areas. The use of steam traction at Pen yr Orsedd until c. 1960, at Penrhyn until 1965 and at Dinorwic until 1967 latterly brought railway enthusiasts in their droves to these sites, but the photographs they took are largely three-quarter views of locomotives. One important record, however, is the Real Photographs collection showing the de Winton locomotives at Pen yr Orsedd in the 1930s, published in Boyd 1981, which make clear how these distinctive and locally-built locomotives were designed.

The film and video archive of the slate industry is slight, and what there is tends to be jealously guarded. The first Welsh-language feature film, *Y Chwarelwr*, made by Ifan ab Owen M. Edwards with an amateur cast in 1935, shows one of the Ffestiniog quarries, though a video of the first eight minutes, apparently all that survives, lent by the British Film Institute, shows little of the quarry itself. Sound-effect and dialogue were on records, which have been lost. The only surviving copy of *Men Against Death*, a narrative based around the work of Dorothea quarry made two years earlier by C.H. Dand, and which includes a shot in which the cameraman strapped himself into a wagon on a blondin, is owned by Tir Glas in Caernarfon, but it has unfortunately been stretched and cannot be shown.¹⁶

A number of films taken by the railway enthusiast Ivo Peters at Penrhyn and Dinorwic are commercially available. Gloddfa Ganol Mountain Tourist Centre shows a video of Oakeley quarry at work before the second war and a run on the Maenofferen counterbalance incline, with a commentary by Wynford Vaughan-Thomas. A film of the last run on the Llechwedd exit incline in 1964 is in private hands.

¹⁴ The survey is grateful to Dr Mary-Elizabeth Hellyer for this clarification.

¹⁵ Reproduced in Lindsay *op. cit.*, p. 33.

¹⁶ David Berry, *Wales and Cinema* (University of Wales press, 1994), p. 7, p. 284, information from Gareth Haulfryn Williams, Gwynedd Deputy Archivist.

Finally, one of the most effective means of interpreting a particular site's archaeology is conversation with people who work, or worked in it, and the work of the survey was much assisted by discussions with former or present quarrymen and quarry managers.

5.0. ANALYSIS OF FEATURES AND RECOMMENDATIONS

Features within slate quarries were assigned to a number of different categories according to their function, namely:

- 1.) Extraction/tipping.
- 2.) Processing.
- 3.) Power.
- 4.) Transport.
- 5.) Structural features.
- 6.) Administration.
- 7.) Ancillary.
- 8.) Domestic.

These are considered in turn; the resource of the category is summarised, the terminology listed and where necessary defined, and the features themselves analysed. Those considered to be of national importance are listed at the end of each section.

5.1. Extraction/tipping

Summary:

This category includes the removal of the raw blocks suitable for processing and of the badrock and toprock for tipping. The two latter categories comprised at least 90% of the total extracted.

Terminology:

This category comprises the following features:

Chamber: an underground extraction point. In that the survey excludes underground features, these are only noted in the exceptional cases (*e.g.* Clogwyn y Fwch) where they open directly onto the surface.

Fanhouse: a structure containing a device to ventilate a mine.

Gallery: a ledge in a stepped open quarry.

Quarry area: an ill-defined area of working.

Quarry face: a working which is approached from its foot.

Quarry pit: a working which is sunk below ground level, and from which slate has to be raised for processing.

Shaft-head: an attempt was made to distinguish between haulage shaft-heads (see 5.4 Transport) and roofing shaft-heads, *rwff*, pl. *ryffiau*, points where chambers are worked into the open air.

Tip: place where useless toprock and other rock unsuitable for processing is dumped.

Tip-run: a means of access, by rail or other transport system, to a tip.

Trial: an area of working which appears never to have progressed beyond exploration of the rock.

Analysis:

Though published works on the slate industry have tended to divide quarries into gallery (stepped hillside working) types, pit types and underground types, and suggest that these are largely co-terminous with the three main districts of Bethesda-Llanberis, Nantlle and Blaenau Ffestiniog respectively, it was found that there was a considerable variety in the way quarries were worked even within particular areas.

Within the Bethesda area, though Penrhyn itself (20061) was worked both as a hillside gallery quarry and as a galleried pit, Bryn Hafod y Wern (20045), Dolgoch (20053) and Tan y Bwlch (20062) were worked as sheer-sided pits. Insufficient remained at Pan Dreiniog (20059) to tell what arrangements had once prevailed there, and the small-scale Moel Faban/Ty'n y Ffridd cluster (20058, 20063) never progressed beyond simple faces in the slopes behind Caellwyngrydd.

This pattern is echoed in the Llanberis area, with both hillside and pit workings at Vivian (20087) and Dinorwic (20091) and pits, sometimes sheer-sided, sometimes with traces of a gallery system, at the quarries on the west side of Llyn Padarn (20065-20075). Prince of Wales (20221) and Gorseddau (20238), both in the Pennant-Gest area, are gallery quarries.

In Dyffryn Nantlle and in the quarries on the Crown Lands to the north (20175-20181) pit workings are near-universal, though in the Cwm Gwyrfaï area, at Glanrafon (20196), the quarry consists of a galleried pit with some galleried hillside workings.

It was considered that galleried workings are now seen in their purest form at Prince of Wales (20221) and Gorseddau (20238), both in the Pennant-Gest area. Of the pit types, Gallt y Fedw (20032) was observed to be an excellent example of Nantlle practice.

The survey did not include underground features, and therefore in sites where slate was mined rather than quarried, the extraction points do not figure in the report. However, it might be as well to outline the process as it was carried out in the Glaslyn and Blaenau Ffestiniog areas, and, and as it still goes on at one site, Maenofferen quarry (20306), and the slightly different methods still followed at Aberllefenni in the Corris district (20487). Mining becomes necessary where the veins dip and workings therefore have to follow the slate along the vein; at Blaenau the dip is from between 20° and 35° , whilst the dip of the plane of cleavage is about 45° . Once it becomes uneconomic to remove the overburden and toprock, an adit is driven, either level or inclined, from which openings are commenced, which may become anything up to 60' wide and 50' deep. Between them supporting walls are left, between 30' and 50' across. The openings are known as "chambers" and the intervening walls as "pillars" from an earlier method, eventually recognised as inadequate, of supporting the roof, in which columns of slate, rather than complete walls, were left in place. This pattern was duplicated often on many levels, so that in cross-section a slate mine resembles a honeycomb.

At Aberllefenni the dip is 70° , and chambers can be worked to a much greater depth. The present system involves a railway leading to a ledge near the top of a chamber, to which a crane hauls the blocks once they have been extracted by means of a chain-saw.

There is, nevertheless, considerable evidence of early nineteenth-century open working in these quarries, though often evidence was observed to have been destroyed by more recent untopping with heavy plant. At Rhosydd the process of development may be traced from the early open workings at the higher, southern end of the quarry down to the adits which served the later underground operations.¹⁷ Similarly at Rhiwbach, the older pit workings lie to the south¹⁸ whereas the trace of an incline reaching to a more recent adit can be seen clearly on the northern part of the site.¹⁹ Rhiwbach quarry's uphaulage incline to

¹⁷ 20283:2-7, 15, 16, 40, 47.

¹⁸ 20313:45

¹⁹ 20313:24, 58.

the main mills²⁰ illustrates very well the way in which slate had to be won from underground, and overall this site emerged as best illustrating underground slate-extraction, when considered in conjunction with other features of the quarry.

Features that relate to underground extraction were noted only if they were apparent on the surface. Adit mouths, for instance, are frequently apparent, and often form impressive features.

Another instances of surface features which relate directly to underground working is the Guibal fanhouse at Croesor quarry,²¹ unique within Gwynedd, made necessary by the use of underground steam engines. However, very little remains of the house itself and nothing of the machinery. It has therefore not been included in the recommendations in **Appendix 1**. A particularly fine row of *ryffiau*, roofing-shaft heads, was observed at Cwt y Bugail quarry,²² where they clearly illustrate the way in which the chambers worked the vein of slate. These were graded highly in terms of group value with the rest of the quarry.

It is in the Dyffryn Conwy area that the greatest variety of quarry arrangement is to be found, doubtless because here managers and men were chasing narrow and faulted veins of indifferent slate. At Coed Mawr (Ty'n Ddol, 20099) near Dolwyddelen, a Nantlle-style pit is to be found on the valley floor, a miniature version of Dorothea; Cwm Eigiau (20100) consists of hillside galleries, whilst at Rhiwgoch (20131) slate was mined. However, because this area tended to imitate rather than lead, nothing survives here that is not better represented elsewhere.

The only exception to this generalisation are the underground workings in Llanrhychwyn. Though they do not come within the remit of the present study, it is worth pointing out that they preserve something of the early nineteenth century methods, abandoned elsewhere, of very large chambers, and pillars (as distinct from from an intervening wall, still referred to as "pillars" in quarry parlance) supporting the roof, a method which derives from the Lake District and which has archaeological parallels there. This was observed at Pen y Ffridd (21053) where chambers have been carved out under a dolerite sill, supported by pillars of slate. At Clogwyn y Fwch (20144) these chambers open out onto the surface, forming a remarkable series of mouths up the side of Mynydd Deulyn.

Abundant evidence survives for the use of the jumper, the hand-held drill used for make the holes for blasting, as well as for powered drills, but it did not prove possible to distinguish between them. The holes are visible as semi-circular grooves at right angles to the plane of cleavage. Only at Llechan quarry was there no evidence for their use,²³ suggesting that this site never used explosives, either because of its antiquity or because the foot-joints and pillars in the rock are so pronounced and close together that black powder would have shattered the rock.

The bulk of the rock extracted went over the edge of the tips. Though the transport implications of tipping are considered in **5.4. Transport**, it is worth pointing out here that the form of can reveal evidence of early quarrying techniques. One example of this is to be found at Clogwyn y Fwch, where at the bottom level a remarkable corbelled tunnel was found to have been built over a tip run.²⁴ No other examples were recorded in Gwynedd, but the practice is known in the Lake District, and the feature strengthens the possibility that Clogwyn y Fwch was the Lakelander William Turner's stop-off point before he took on Diffwys Casson in 1800.²⁵ This feature has therefore been included as of national importance. As as much a transport as an extraction/tipping feature, it is listed in section (5.4).

²⁰ 20313:24

²¹ 20279:4

²² 20311:19, 21, 23, 24.

²³ 20138:3

²⁴ 20144:2

²⁵ Lewis and Williams, *Pioneers of Ffestiniog Slate* and correspondence from Dr Lewis.

No features within this category have so far been accorded statutory protection.

5.2. Processing

Summary:

Processing the raw blocks into roofing slates involved a number of activities - initial reduction (*brasholtti*), which could be carried out either by hand or mechanised saw, splitting (*manholtti*), a process which was never successfully mechanised, and dressing *i.e.* square-trimming the edges (*naddu*), carried out either manually with a knife or mechanically. Producing slabs involved sawing, nearly always mechanical, and possibly also further processes such as polishing or enamelling or the carving of "fancies". In a number of the sites surveyed, very simple and comparatively sophisticated methods co-existed, whether because of the various types of rock found together, the amount of capital for investment, the technical knowledge available at the time. Particular types of rock, such as the *carreg meddal* of Arfon, also lent themselves to crushing, for use in paint or cosmetics.

Terminology:

This category comprises the following features:

Dresser: a machine, either guillotine type or rotary.

Dressing area: area where slates were hand-processed.

Gwal: a slatemaker's shelter.

Machine area: area where machines stood in the open air.

Machine base: a plinth, or arrangement of holding-down bolts, to secure a machine.

Mill: a building to accommodate slate-processing machinery. Within mill buildings an attempt was made to distinguish certain internal or related features, namely:

- a.) **mill dressing alcoves:** separate areas, generally divided from each other by a constructed wall or a partition, where splitting and dressing were carried out.
- b.) **mill waste chute:** a means by which the offcuts from the saws and waste from the trimming process could be disposed of.
- c.) **mill line-shaft area:** the line-shafting from the power source, though it frequently ran internally, at floor- or truss-level, might also be housed in a separate parallel structure.
- d.) **mill waste tip:** sawn ends and trimming waste; only separately noted if they contain evidence of unusual machinery.

Mills were further divided into types according to the arrangement of their railways -- see text.

Tip contractors' workings: secondary working (of tips and buildings) by local unemployed quarrymen (*hogia' domen*, "tip boys") for roofing slates, from the Great Depression onwards. These are characterised by a multitude of small *gwaliau*, which are not individually noted.

Analysis:

The survey revealed only limited evidence for manual or mechanical processing carried on in the open air. Evidently, the construction of *gwaliau* begins at an early stage in the industry's history. At Gallt y Fedw in Dyffryn Nantlle there is archaeological evidence for slate-processing machinery standing in the open air,²⁶ a feature which adds to the value of this important site.

²⁶ 20037:7

Evidence of *gwaliau* was found throughout the industry wherever roofing slates formed part of the output. Most are crude shelters, generally three-sided, possibly not always roofed, standing either alone, in a cluster or in a row. Those at Vivian quarry are substantially built, with timbers supporting thick slab roofs, of a quality and order which strengthens the possibility that Vivian was regarded as a "showcase" quarry for visitors.²⁷ These are already scheduled. Those at Gorseddau also seem to have been the result of planning, as they are comparatively large and uniform structures, each with a ledge for tools built into one wall.²⁸ They are mentioned in the list below in that they show how these generally simple features could be made more elaborate in a site where the lessees were prepared to spend heavily. The only others that are in any sense remarkable are those at Foel, which have two walls and unusual cantilevered slab roofs,²⁹ which have also been included as of national importance. It is possible that there may have been wooden partitions along the back of these structures. However, no typology was discerned amongst *gwaliau*, and the probability is that many of them were built informally by the quarrymen. As a typical example, the *gwal* on floor 4 at Blaen y Cwm measures 11' 3" by 11' 3".³⁰ The areas suggested as being of national importance, namely the working bank at Dorothea, Australia, Egypt and Lernion levels at Dinorwic, part of the gallery and incline system at Prince of Wales, and the working buildings at the top end of Rhosydd, include a number of typical examples of this feature.

In Nantlle *gwaliau* were observed partially incorporated into mill structures, such as at Gwernor and at Gallt y Fedw.³¹ What are effectively internal *gwaliau*, the mill splitting alcoves, were identified at Maenofferen and Pen yr Orsedd, where they are still in use, as well as at Rhos mill, Capel Curig, and the Australia mill at Dinorwic,³² both of which are suggested as of national importance. The most obvious reason for their continued use is to avoid confusing the men's make, though their survival can probably also be attributed to the strength of the bargain system and the quarrymen's own self-image as independent contracted craftsmen.

Mills - that is to say, structures to house slate-processing machinery - were observed to take many different forms, and evidently served very different functions. Broadly speaking, they might carry out any combination of:

- 1.) initial reduction, either by hand or machine, of the raw block.
- 2.) mechanically sawing a reduced block into a rectangular pallet, either for sale as a slab (in which case it might also be mechanically planed) or for further processing to make roofing-slates.
- 3.) Hand-splitting of the pallet into laminae for roofing-slates.
- 4.) Mechanical- or hand-trimming of the edges of the roofing slates.
- 5.) The production of "fancies", and enamelling slabs in a kiln.

Unless machinery survives, or some other distinctive feature, such as a means of disposing of trimming waste, it proved difficult to distinguish between mills for slate production and for slab production. Anecdotal evidence supports the possibility implied by the surviving archaeology, that mills could be adapted for whatever purpose was required - that a roofing-slate mill might produce slabs when necessary.

The decision was therefore taken in the course of the survey to analyse mill buildings by the way in which railways were laid in them, rather than by process-flow. Four patterns of arrangement were identified, "transverse", "longitudinal", "radial" and "bay", though it was clear that by no means all mills

²⁷ 20087:25, 36, 41, 42, 52, 57, 58.

²⁸ 20239:9, 13-16, 21, 23, 24, 26, 30, 36-38, 43, 44, 46-48.

²⁹ 20105:19

³⁰ 20132:30

³¹ 20035:4, 20032:8.

³² 20039:41, 20110:26, 20091:85, 20306:32

corresponded to one or other of these categories, and that several were too badly dilapidated to be analysed.

Transverse and longitudinal mills are generally long rectangular structures, with a power source either in the centre or in the gable end. In the transverse type, the railways run across the mill, supplying blocks to the initial stage carried out there. The process itself runs parallel to the transverse railway, though is probably not assisted by it, and the rails were only used for the removal of the empty wagons after the blocks had been unloaded. The best example of such a system is the two mills on Penrhyn quarry's Coed y Parc site³³ which have therefore been recommended for listing. Hafodlas and Rhiwbach include such mills, the first being of particular value both for its association with other features and as evidence of the Hunter patent saw, the second for its importance within the site as a whole and as an example of a feature powered from a shared common source.³⁴

Longitudinal mills are supplied by a railway, or railways, which enter and leave through the gable ends of the building, though the process might take place in a transverse direction. The Australia mill at Dinorwic is one such; two parallel but unconnected lengths of railway occupy the centre of the mill, one to supply the banks of saw tables along one wall, the other to remove the finished slates from the dressing alcoves on the opposite wall.³⁵ The process-flow is therefore at right angles to the railways. This feature is of considerable importance on account of its near-complete survival together with machinery. The longitudinal mill at Diffwys Casson quarry is of considerable historical significance in that it is regarded as the first integrated mill in the industry,³⁶ unless the palm belongs to Minllyn³⁷ where waste chutes were found in a pre-1845 mill.

The bay mill, as its name implies, is one in which a length, or lengths, of railway enter the mill from one side only, and the raw blocks travel in and the finished product out, by the same means. The older mill at Hafodlas, Betws y Coed is an excellent example of this method, and a much smaller version is to be seen at Foel, near Capel Curig, though a typical example is to be found at Parc.³⁸ Hafodlas has been recommended because of the survival of machine bases, and Parc as the best example of the typical. Possibly this system may have been more extensively used where sand-saws were employed, and the flat wagons which transported the blocks from the extraction point were themselves run under the saw-carriage with their load and supported the block during the sawing process.

The radial mill is a variation on the bay-type, in that a single railway enters the building, and a central wagon turntable gives access to machines arranged around the perimeter. Examples were identified at Cwm Machno and possibly at Aberllefenni,³⁹ and a substantially complete example at Cefn Madoc,⁴⁰ where one end has been converted into a dwelling but in the other it is still possible to see the claw bracket marks on the trusses and the axle box holes. Like the bay mill, its use was probably confined to slab production, though it has effectively been revived in the modern "integrated" mill with the replacement by forklift trucks of 2' gauge railways.

Many variations in these patterns were noted, some of them bizarre - the middle mill at Ratgoed, designed as a transverse mill, but built up against a cliff face so the far tramway doors opened out onto rock.⁴¹ A number of instances were noted of mills in which it was not possible to analyse internal

³³ 20061:7, 9

³⁴ 20156:3, 20313:11

³⁵ 20091:84-87.

³⁶ 20305:1, Williams 1991 p. 14.

³⁷ 20456:6, 7

³⁸ 20156:1, 20105:8, 20259:11

³⁹ 20132:4, 20487:12

⁴⁰ 20165:2

⁴¹ 20489:16

arrangements, either because of poor survival - Portreuddyn,⁴² for example, where the mill has been substantially altered to make two cow-sheds - or because of an unusual design, such as Gorseddau,⁴³ already scheduled, where a three-storey mill has railway access to both the ground and the first floor, and some sort of vertical circulation would have been practised.

These buildings were nearly all found to be severely functional with rarely any attempt made at decoration, beyond occasionally a date-stone. A number (Prince of Wales, Ty'n y Coed/Arthog, Ratgoed lower mill)⁴⁴ had flattened-arch doorways for the transverse tramways. Only at Hafodlas and Gorseddau is there any more serious attempt at ornamentation; the Hafodlas mills have attractive corbelled openings, whilst Gorseddau is an extraordinarily flamboyant structure of ecclesiastical proportions and appearance.⁴⁵

Building materials other than slate or country rock are rare; at Glanrafon brick pillars to support the roof-trusses survive *in situ*,⁴⁶ and though corrugated iron mills are known from archival sources, only the upper mill at Llechwedd remains.⁴⁷ Where roof-arrangements survive, king- or queen-post trusses of a standard nineteenth-century design support a slate roof, sometimes patched with corrugated-iron. The Australia mill at Dinorwic has steel roof-supports.⁴⁸ Skylights are common, as the thick low supporting walls are not always suitable for windows. Hipped roofs are common, especially in exposed locations.

Sawing machinery rarely survives in abandoned mills. Australia mill at Dinorwic⁴⁹ is unique in that its thirty-six Ingersoll Rand saw tables remain *in situ*, mostly in very good condition, still with line-shafting and the vacuum extractor systems. A large double saw-table and a planer survive in the ruins of the Bonc yr Offis mill at Pen yr Orsedd,⁵⁰ which accordingly appears in the list despite the low survival of the building itself. Broken sand-saw blades were observed at Pompren near Dolwyddelen⁵¹ but insufficient remained to indicate how the saws were powered or functioned. Otherwise little remains in any site visited.

Evidence for the type of saws used in a particular quarry was sought in the sawn-end offcuts on tips, and in rubble used for building quarry structures. In most cases the saw used was a standard circular pattern, probably the Greaves patent, which involved a slotted table moving against the blade. Offcuts from sand-saws (horizontal saws, in which blades are tensioned in a carriage suspended from a frame and then moved backwards and forwards across the block), with their distinctive smooth lay and ridge where the cut was snapped, were observed at a number of quarries in Dyffryn Conwy and its tributary valleys, particularly Cwm Eigiau (20100) and Cedryn (20106), and it is known from archival sources that sand-saws, once general throughout the county, remained in use far longer here, because they could cope with large slabs and deal better with pyritic rock than circular saws. The Hafodlas mills include the bases for such machines, but no substantial sand-saw remains were observed in any of the sites visited. The Hafodlas mills also provide the best evidence for the use of the Hunter patent saw, with their distinctive machine bases.

Whilst it is quite possible that some of the structures built out of diamond saw offcuts in quarries date from before the terminus of this study, it is more likely that they are later. These are recognisable by

⁴² 20241:1

⁴³ 20238:54

⁴⁴ 20221:3, 20375:12, 20489:1.

⁴⁵ 20156:1, 3, 20238:54.

⁴⁶ 20196:12.

⁴⁷ 20300:47.

⁴⁸ 20091:84.

⁴⁹ 20091:84.

⁵⁰ 20039:20

⁵¹ 20108:2.

their shallow circular striations and the general smoothness of the cut. Diamond saws seem to have been introduced in the 1920s, but their use did not become common until after the war.

Very few dressing machines were found *in situ* in abandoned mills, though a number of guillotine dressers were noted, semi-preserved, at Goleuwern, and one at Diffwys Casson.⁵² The latter is the better example as being within its original context. Circular dressers were noted in use at Pen yr Orsedd, and a single-bladed example out of use at Twll Llwyd, installed in the 1970s, where the traditional *cyllel* and *trafal* have superseded it.⁵³

Little evidence was discovered for machinery to do anything other than produce slabs or roofing slates. "Fancies" for producing ornamental fireplaces were noted at Maes y Gamfa, implying a planer with a shaped blade, but no other evidence was observed, and the traces of a crusher survives at the Gallt y Fedw site in Dyffryn Nantlle.⁵⁴ Enamelling kilns are preserved at the Inigo Jones slate works at Groeslon, but no examples were discovered in the course of the survey, with a possible saver on Hafodlas, Betws y Coed.⁵⁵

The disposal of mill waste was often carried out by means of a railway, sometimes running along a pit below floor level, a method seen most clearly at Blaen y Cwm.⁵⁶ More often they run at floor level. Mill tips, as well as providing evidence for the machines which processed the slate, also give some indication of how successful the mill was, by the size of its tip. Gorseddu mill, though of huge size, was evidently a dismal failure, to judge from the paltry amount of rock it threw onto its tip from 1856 until final closure in 1869.⁵⁷

One last category deserves mention, the tip contractors' workings. In a sense, these belong to the category of extraction as much as to processing, but they have their place here in that they nearly always seem to work existing tips or structures rather than quarry fresh rock. Apart from the reworking of the lower mill at Rhosydd,⁵⁸ these seem to have been largely confined to Arfon, to the Llanberis, Nantlle and Moel Tryfan regions. Examples were noted at Cefn Du, Cook and Ddol, Cae'r Meinciau, Blaen y Cae, Clodda'r Lon, Fron and Alexandra.⁵⁹ Fron is particularly good example, showing the disturbed levels on the tip runs, and the multiplicity of shelters and barrow-ways, though in view of the threat to this site, Blaen y Cae has been recommended.

The following in this class are already scheduled:

20087 VIVIAN	42	GWAL
20087 VIVIAN	25	GWALIAU
20087 VIVIAN	36	GWALIAU
20087 VIVIAN	41	GWALIAU
20087 VIVIAN	49	GWALIAU
20087 VIVIAN	52	GWALIAU
20087 VIVIAN	57	GWALIAU
20087 VIVIAN	58	GWALIAU
20238 GORSEDDAU	56	MILL
20033 DOROTHEA	13	MILL LONGITUDINAL

⁵² 20367:13, 20305:2.

⁵³ 20039:41, 20018:1.

⁵⁴ 20044:88, 20032:4.

⁵⁵ 20156:13.

⁵⁶ 20312:8; the mill areas at Rhiwbach (20313:18) and Minllyn (20457:8) include similar features, but in neither site do they show to the same advantage as at Blaen y Cwm.

⁵⁷ 20238:56.

⁵⁸ 20283:51?????

⁵⁹ 20490:17, 23, 32, 20069:37, 38, 20071:29, 20031:4, 16, 20036:30, 35, 20178:2, 5, 9, 10, 21, 37, 39, 40, 20181:11.

5.3. Power

Summary:

Power needs in slate quarries were various, and a number of different methods of generation and transmission were employed to meet them, according to the amount of capital the quarry had to invest, constraints of space and topography, and the technology available at the time.

Terminology:

This category comprises the following features:

Bell crank base: a means of transferring power from flatrods to vertical pumprods.

Chimney

Compressed air cylinder

Compressed air system

Compressor

Compressor house

Electric motor

Electricity substation

Flatrod supports

Fuel tank

Launder system

Mill engine house

Pelton wheel site

Pillar

Pump

Pump-engine house

Sluice

Steam engine site

Water abstraction point

Water channel

Water pipe

Water storage

Waterwheel pit

Analysis:

It was observed in the course of the survey that mechanical power was generated variously by water, external combustion engines (steam) internal combustion engines and electricity, and that power was transmitted by flatrods, ropes, air, water and electric power lines.

It is clear that in many cases the same power source was used for several locations and functions, especially but by no means uniquely, in smaller and more marginal concerns, and that often complicated systems were employed to transfer power from the source to the point of application. An excellent example is Rhiwbach quarry, in which the one power source, initially a steam engine, latterly an electric motor, not only powered the mill machinery but also a shaft and three inclines.⁶⁰ A further example survives at Pen yr Orsedd, in the form of a series of towers that led a series of wire-ropes enabling a

⁶⁰ 20313.

waterwheel in a mill on one level to operate a mill on the level below.⁶¹ A further complication is that in a number of instances different power-source types have been employed in succession within the one feature. Therefore in the analysis that follows, the observed remains of the quarries' use of power is analysed in terms of function rather than type.

Power was required within slate quarries for a number of functions:

- 1.) for **extraction** of the rock at the face
- 2.) to operate **mills** and other processing plants
- 3.) to operate **pumping equipment**.
- 4.) to turn machinery in **workshops**.

Transport was also a major power-need; however, this is treated separately in (4.) **Transport**.

1.) **Extraction.** Archive sources confirm that early powered rock-drills were steam-operated, but no archaeological evidence has emerged on site, perhaps because the boilers were rail-mounted and possibly even self-propelling. One Ingersoll Sargent drill survives in private hands as a preserved item.⁶² For the use of pneumatic drills, considerable evidence survives on a number sites. At Bryneglwys and at Rhos, Capel Curig, the sites of compressors operated by water-wheels survive,⁶³ and Cwm Machno and Pen y Bryn evidence was found of pelton-driven compressors.⁶⁴ Surviving compressors are all of the reciprocating-piston type; at Pen yr Orsedd there remains an Ingersoll-Rand horizontal-cylinder compressor, originally steam-powered, complete with electric motor,⁶⁵ whereas at Dinorwic a number of compressors survive. Those on Australia level are particularly impressive, including one two-cylinder vertical, a two-cylinder horizontal; fragments of the electric motors which powered them, a large receiving tank and a water tank for cooling purposes, together with a network of pipes and junctions to carry the air to the rock faces.⁶⁶ These are included in the area of the quarry suggested as being of national importance. A number of compressors survive at Llechwedd.⁶⁷

For the loading of rubble, mechanical excavators are now common, but the only archaeological evidence for the use of "American devils", early steam version of these machines, was a number of special rubble wagons designed to be used in conjunction with them at Dinorwic.⁶⁸

2.) **Mills.** It is probable that manually-operated slate saws on sites where offcuts are visible but no external power-source is apparent,⁶⁹ and there is documentary evidence for an early horse-powered saw-table at Diffwys (Casson),⁷⁰ of which no remains survive. It is clear, however, that water-wheels provided the main power-source in many quarries in the nineteenth-century, and that their use continued well into the twentieth - indeed, the use of water-wheels was widespread and long-lived by the standards of any British industry, and frequently the remains of stoutly constructed wheelpits survive in much better condition than the mills they served. Their use seems to have been general in all regions of Gwynedd, with the single exception of the quarries on the Moel Tryfan uplands, where there was insufficient fall to make much use of rainwater.

⁶¹ 20039:9, 16, 18, 21

⁶² Information from Gwynfor Pierce Jones of Pen y Groes.

⁶³ 20430:12, 20110:24

⁶⁴ 201332:33, 20037:22, 23.

⁶⁵ 20039:45.

⁶⁶ 20091:24, 61-68, 71.

⁶⁷ 20300:33.

⁶⁸ 20091:95.

⁶⁹ E.g. 20100:20, 20262:11

⁷⁰ 20305, Jonathan Davies, *op. cit.*

Nearly always the wheels were situated either in the gable ends of buildings, or across the middle, to minimise problems with torque. Very few exceptions were found to this rule. At Foel, Rhos, Rhiwgoch, Blaen y Cwm and Queen's, wheelpits were built against the longitudinal wall,⁷¹ interestingly, the first three of these were all on the Gwydir estate, and possibly the same engineer built all three, though insufficient data remains in the shape of machine bases or other internal arrangements to suggest why this should have been so. At Cwm Eigiau, Penrhyn Gwyn and possibly Abercwmciddaw the topography dictated that the mill should be built some distance from the wheels.⁷² At Penrhyn quarry (Coed y Parc site) a wheel in a pit below ground level powered two parallel mills, one on each side.⁷³ This is the only surviving mill-waterwheel in the industry, unless one counts those at Aberllefenni where the parts which projected above floor-level have been scrapped and the remainder buried and concreted over.⁷⁴ The Penrhyn example therefore best exemplifies its type, both as an example of a remote wheel and because of its group value with its two mills.

The size of the pits suggests that waterwheels were anything up to 50' diameter, and that 30' was common. One 15' waterwheel pit was noted, near Tan yr Allt in Dyffryn Nantlle.⁷⁵ What is harder to establish, because of the dilapidated nature of the supports for header tanks and troughs, is the type of wheel. In exposed locations it is probable that pitchback or high breastshot wheels were most commonly employed, as high winds would lessen the efficiency of an overshot wheel. This much is suggested by sites where the precise location and dimensions of a wheel can be ascertained, either from axle-boxes or scratch marks, and where the water-supply system is more or less intact, such as at Cwm Eigiau.⁷⁶ No evidence was found for low breastshot, undershot or stream wheels.

Water-power had the advantage of being relatively cheap compared to coal and if the fall were sufficiently great a sequence of wheels could be installed on the one water-course. A particularly fine example at Votty and Bowydd in Blaenau Ffestiniog⁷⁷ which once served a sequence of three mills suffered much damage in the 1980s, though another example survives in excellent condition at Rhos,⁷⁸ where one course powered four wheels, the first operating a chain incline, the second and third a mill and the fourth a compressor. This has been recommended for scheduling on the grounds that it best exemplifies the use of a sequence of waterwheels within the one stream, and to a variety of purposes. The same is true of the hydraulic system at Parc, where its value is enhanced by its group value with the site's distinctive mills.⁷⁹

An unique application of water power to working slate-saws is to be seen at Pen yr Orsedd quarry where one massive double saw table survives in the mill at Bonc yr Offis with the remains of a hydraulic drive to the table itself; part of an accumulator is to be found nearby. The saw drive came originally from a water-wheel pit on which an electric motor was later placed.⁸⁰

Pelton wheelpits to power mills were found at a number of sites; at Hafodlas, Betws y Coed, the pelton is clearly built over the site of a wheelpit⁸¹ and at Minllyn it evidently replaced a steam-engine.⁸² Otherwise they are purpose-built. Examples were noted at Foel, South Snowdon, Gartheiniog and

⁷¹ 20105:9, 20110:21, 20131:14, 20312:17, 20360:2.

⁷² 20100:7, 9, 20380:4, 20468:34, 35.

⁷³ 20061:7-9.

⁷⁴ 20478:1

⁷⁵ 20020:13.

⁷⁶ 20100:5, 7.

⁷⁷ 20303:6, 7, 19-21.

⁷⁸ 20110:17-24.

⁷⁹ 20259:19, 24.

⁸⁰ 20039:20, 21.

⁸¹ 20156:2.

⁸² 20457:11

Ratgoed,⁸³ but their comparatively small size compared to waterwheel pits means that some may have been overlooked and others obliterated.

Evidence of steam engines to power mills was met on only fifteen sites, in which only two provided any indication of more than one steam mill. The Llanberis area produced two examples (one only in the shape of some firebars), Moel Tryfan/Cwm Gwyrfai, Glaslyn, Dyfi and Corris one apiece, Bethesda, Dyffryn Conwy, Pennant/Gest, northern Meirionydd, the Mawddach area, none. Four quarries in Nantlle and six quarries in Blaenau provided evidence of steam mills.⁸⁴

However, bibliographical and archival evidence makes it clear that mill steam engines worked on sites where there is now no evidence for them, and the contrast between the numbers that are known from written sources compared to the limited archaeological evidence raises a number of questions. In the case of Dyffryn Nantlle, published research⁸⁵ suggests that the total should be twenty-two. However, Coedmadoc (one engine), Cilgwyn (two-engines) and Cornwall (one engine) have all been more or less obliterated as sites. At the two parts of Fronlog, at Tan'rallt and Ty'n y Weirglodd (each with one engine) and Tal y Sarn (two engines) the structures have left insufficient remains to indicate steam engines, and though the once-steam-powered mills at Dorothea (two engines) and Pen yr Orsedd (three engines) survive to a greater or lesser extent, electric motors or internal combustion engines have been installed on the engine-bases.⁸⁶

This suggests that archaeological investigation may only be able to recover a very small part of the resource. Yet, whilst it is true that instances survive in other areas of steam engines which have left no physical trace, for instance at Dinorwic and at Portreuddyn, and that sites such as Diffwys (Casson) had more than two steam engines, it seems probable that the peculiar circumstances of Dyffryn Nantlle have distorted the record. There were some early closures and scrappings after the boom of the 1870s, considerable modernisation in the quarries which were still in business in the early twentieth century, and extensive reworking of tips and structures by the *hogia' domen* from the '30s onwards. Add to that the resale value of a steam-engine, either as a working machine or as scrap, and it becomes clear that they were particularly at risk, especially in the Nantlle region, though the same factors may have operated in the Ffestiniog area to some extent.

The record may also be obscured by the use of portable steam plant. It is likely that one of the mills at Rhosydd and the mill at Cefn Madoc were powered by portable engines, since there is no other evidence of a power-source, and ash was found in the course of the 1972 survey of Rhosydd.⁸⁷ Conversely it is possible that where a chimney and an engine house exist, the engine itself was never installed. There seems to be little internal evidence that Abercwmiddaw ever put in a steam engine to power machinery in the surviving structure on the quarry bank.⁸⁸

It is, nevertheless, remarkable what little use the Gwynedd slate industry made of fixed steam power to operate mills. The reason is unlikely to be technical conservatism since steam power was extensively used for uphaulage in Nantlle and Ffestiniog. (See [4.] **Transport**) Rainfall was free and abundant, and where a comparatively low-power system would do, since it was only being asked to turn a number of saw tables, waterwheels were retained. Where considerable power was needed at a moment's notice to power an uphaulage system, steam took over.

⁸³ 20105:25, 20255:5, 20449:8, 20489:19.

⁸⁴ Cefn Du (20490:25), Glynrhonwy Lower (20075:15, 17), Gallt y Fedw (20032:5), Cloddfa'r Lon (20036:31), Pen y Bryn (20037:25), Pen yr Orsedd (20039:21), Moel Tryfan (20179:5), Fron Boeth (20278:2), Wrysgan (20289:28), Oakeley (20296:31, 44), Diffwys Casson (20305:3, 16), Cwt y Bugail (20311:9), Blaen y Cwm (20312:3), Rhiwbach (20313:1), Minllyn (20457:11), Abercwmiddaw (20468:14).

⁸⁵ G.P.Jones 1985.

⁸⁶ 20019, 20034, 20027, 20014, 20020, 20024, 20025, 20033:37, 38, 20039, G.P. Jones, *op. cit.*

⁸⁷ 20283:18, 201652:2, Lewis and Denton, 1974, p. 48.

⁸⁸ 20468:12.

Of the steam engines themselves, no remains were observed on site, except at Pen y Bryn, where fragments of valve-gear and part of a flywheel had been excavated.⁸⁹ Where an engine base survives (e.g. Gallt y Fedw)⁹⁰ the remains suggest the use of conventional late-nineteenth century horizontal engines, much like the single-cylinder de Winton engine in the workshops at Glynllifon, though the one surviving mill engine, preserved at Amgueddfa Lechi, Llanberis, is a Mather vertical condensing rotative engine of c. 1850, formerly installed at Pen y Bryn, Nantlle.⁹¹ It is suggested that this therefore should be considered as of national importance, together with Gallt y Fedw.

Though one instance was observed of a mill going over to the use of hydraulic power, in the form of a pelton wheel, after using a steam engine, at Minllyn,⁹² it seems that a number of mills never used steam power at all, and that a more normal chronology involved moving directly from waterwheels to electricity. Llechwedd and Maenofferen at Blaenau Ffestiniog both fall into this category. The former retains its 1904 d.c. hydro-generating station in full working order, consisting of two Gilbert Gilkes peltons, each operating a Thomson and Phillips 175 kw generator at 385 r.p.m., the whole mounted on a strong cast-iron base, which is suggested for listing. The remains of a 1918 station survive at the latter, but it contains no machinery.⁹³ Of the pioneering a.c. system installed at Croesor quarry, the hydro generating station at Blaen y Cwm survives in reuse,⁹⁴ but little else remains on the site. Other quarries used external suppliers; substations were noted at Dinorwic, Pen yr Orsedd, Moel Tryfan, Alexandra and Oakeley;⁹⁵ the first being recommended in **Appendix 1**, along with the remains of an electric motor nearby. The support for an electric motor, which replaced a pelton and a waterwheel, was noted at Hafodlas,⁹⁶ adding further to the group value of the various structures in this complex.

Internal combustion engines are smaller than steam engines, and their bases less likely to be evident. What appear to be mill engine houses survive at Cook and Ddol and perhaps Abercwmeiddaw. Bases are evident at Dorothea, in a part of the quarry already scheduled.⁹⁷

3.) **Pumping.** Flooding was a problem for quarries which worked on the pit system and for underground mines. Bibliographical references make it clear that the one windmill in the industry was used for pumping at Braich Rhydd,⁹⁸ but it has left no trace. Power for the pumps was supplied variously by water-wheels, steam, internal combustion and electricity, though only the first two of these have left substantial remains, as the more modern machinery could be located underground.

A pump survives at Bryn Hafod y Wern,⁹⁹ completely submerged, possibly powered from the badly dilapidated wheelpit immediately to the south.¹⁰⁰ At Cloddar'r Lon, Dyffryn Nantlle, the pump is partially submerged in heavily polluted water near a bellcrank base.¹⁰¹ The power derives from a sequence of waterwheels on the hillside above the quarry, where the site of a crank base and counterbalance pit for an ambitious flatrod system survive, together with strongpoints for fend-off bobs and cranks to transmit the power to the several points. Nearby the remains of rockers were found,

⁸⁹ 20037:25.

⁹⁰ 20032:5.

⁹¹ 20036:31

⁹² 20457:11.

⁹³ 20300:1, 20306:1.

⁹⁴ 20279:11.

⁹⁵ 20091:2, 20039:46, 20179:13, 20181:17, 20296:4, 13, 56.

⁹⁶ 21056:2.

⁹⁷ 20033:37, 38.

⁹⁸ 20176, Lindsay 1974, p. 154.

⁹⁹ 20045:26

¹⁰⁰ 20045:4.

¹⁰¹ 20036:23

together with rods, and what may be firebars from a steam engine whose site can only be guessed at. The whole complex constitutes a remarkable survival,¹⁰² despite the pollution of the quarry pit. These features survive more complete than the other examples noted elsewhere. At Fron quarry, the only wheelpit recorded in the Moel Tryfan uplands probably operated a pump; it stands outside a tunnel mouth, and the wheel appears to have been powered by two convergent water-system.¹⁰³ A similar system was recorded at Glanrafon quarry, where the wheelpit, supports for the flatrods and a bellcrank base are all apparent.¹⁰⁴ It is possible that a bizarre structure at Ty Mawr East, which was at some stage adapted to accommodate a steam engine, may at one time have housed a water beam-engine.¹⁰⁵

Of steam pumping systems, an example was recorded at Tal y Sarn quarry, including the pumping-engine house, a passage-way for the flatrods under the course of the Nantlle Railway, and the remains of a bellcrank base.¹⁰⁶ This has been included below because of the flatrods and bellcrank base with a steam power-source, as well as for its group value with the nearby dwellings, smithy and church. Pride of place must, however, go to the Cornish beam engine and pump system by Holman's of Camborne surviving intact, a scheduled ancient monument, at Dorothea quarry.¹⁰⁷ This is the only steam pump engine to remain *in situ*, and its condition is declining. The boiler house is now roofless, the sheer-legs have collapsed, and it is at the mercy of vandals. It is, nevertheless, an extraordinary survival, still in fundamentally good condition.

In this context, one other feature deserves mention. The earth tremor of 1984 exposed a cast-iron cylinder approximately 5' diameter behind the slab mill at Tal y Sarn quarry. This was noted by a local enthusiast, who discussed his findings with a number of industrial archaeologists. Excavation is required to settle the matter, but it is at least a strong possibility that this is the base of a Newcomen atmospheric engine, probably installed to pump from the Tal y Sarn pit, possibly used for winding. Though this is unlikely to predate the Boulton and Watt engine installed at the Penrhyn Ddu lead mine on Lleyn in 1782, it is nevertheless likely to be very early,¹⁰⁸ and may be a candidate for scheduling.

In the Glaslyn and Blaenau Ffestiniog areas, little evidence was recorded of power-sources for pumping system. Some workings were entirely or partly self-draining. Llechwedd's Olwyn Goch wheelpit and adjacent shaft-head are prominent features¹⁰⁹ and at Rhosydd there is evidence of hydraulic power applied to pumping, not in the form of a waterwheel but of a Tom and Jerry water-powered engine.¹¹⁰ In neither case, however, were the features considered sufficiently good survivals to merit statutory protection.

4.) **Workshops.** Only the largest quarries had dedicated power-sources for machinery in maintenance workshops, and in only three instances does archaeological evidence survive. At Penrhyn quarry's Coed y Parc complex, a small underground waterwheel survives, which drove machinery in the adjacent workshop¹¹¹ which has been suggested for listing. At Pen yr Orsedd, machinery in the workshop may have been powered by the same source as the adjacent mill.¹¹² By far the most lavish establishment, however, was the Gilfach Ddu complex at Dinorwic, in which a 50' 5" diameter 5' 3" breast high-breastshot wheel survives in working order, complete with header tank and water-supply system,

¹⁰² 20036:2-4, 9-17.

¹⁰³ 20178:13-16.

¹⁰⁴ 20196:13, 21, 22.

¹⁰⁵ 20300:6.

¹⁰⁶ 20025:25, 26, 32.

¹⁰⁷ 20033:31.

¹⁰⁸ 20025:34. Mr Brynley Jones, who first suggested the identification, works as a slate-maker in Pen yr Orsedd quarry. His other finds have included a length of plate rail (see [4.] Transport) and substantial remains of a deWinton locomotive.

¹⁰⁹ 20300:49, 50.

¹¹⁰ 20283:19-23.

¹¹¹ 20061:4.

¹¹² 20039:20, 21, 29.

installed in 1870 to operate machinery in a smithy, foundry and timber sawmill, together with the pelton which replaced it.¹¹³ This has already been scheduled.

The following in this class are already scheduled:

20033	DOROTHEA	37	MILL ENGINE
HOUSE			
20033	DOROTHEA	38	MILL ENGINE HOUSE
20033	DOROTHEA	31	STEAM PUMPING ENGINE
20091	DINORWIC	133	
	WATERWHEEL PIT		
20238	GORSEDDAU	55	WATERWHEEL PIT

5.4 Transport

Summary:

The study examined the way in which raw blocks were moved from the extraction point, rubble was moved to the tips, and the finished product was taken to a point where it could be loaded on to an external transport system.

Terminology:

Abutment

Adit: here used to mean any means of underground access

Adit haulage mechanism: endless rope system for moving railway wagons along an adit

Barrow-run

Bridge

Crane

Cutting

Embankment

Haulage shaft-head: an attempt was made to distinguish between *haulage shafts* and *roofing shafts*. See 1 Extraction/tipping.

Shaft winding engine house steam: only evidence of steam haulage was observed.

Horse-circle: the trace left by a horse when attached to a haulage device, most probably a winding drum

Incline brakesman's shelter

Incline counterbalance: a railway down a gradient, in which the weight of the loaded wagons hauls up the empties on a parallel track by means of a rope passed around a drum or a sheave at the summit

Incline differential gradients: a system observed at the foot of some inclines whereby the gradient of one set of rails alters to the level at a more gradual rate than that of the parallel set

Incline drum housing: for the drum on a counterbalance incline where no covering structure is apparent.

Incline drumhouse: for the purposes of the report, these are regarded as a feature of *counterbalanced inclines*, and *winding houses* as a feature of *uphaulage inclines*.

Incline intermediate level: a siding running off an incline which gives access to an intermediate level.

Incline intermediate sheave: a wheel carrying an incline rope to the summit of the incline from a remote power source

Incline sheave: a horizontal wheel at the summit of an incline for the incline rope, less common than a drum on a horizontal axis.

¹¹³ 20091:132, 133.

Incline *trwnc* dock: a point at the summit, foot or intermediate point of an incline where wagons can be wheeled on and off the *trwnc* (transporter).

Incline uphaulage: a railway to haul wagons by rope up a gradient, further defined by the means of propulsion, as *air-powered, electric, hydraulic, steam, waterbalance*, or, where the means of propulsion is evidently a prime mover but its type is unclear, *mechanical*.

Incline winding drum base: for the drum on an uphaulage incline where no covering structure is apparent.

Incline winding house: further defined as for *Incline uphaulage* by the means of propulsion.

Lift counterbalance: a *Lift* is defined as a near-vertical open incline, in which wagons run inside a form of *trwnc* after the manner of a colliery cage. Only counterbalances were noted in the course of the report.

Lift drumhouse

Loading area

Locomotive

Locomotive blast shelter

Locomotive shed

Locomotive coal shed

Path

Railway: the word *tramway* was eschewed in the course of the survey. *Railway* is used here to express any length of rail transport system, either internal or external.

Railway equipment: any item appertaining to *Railway*, defined in the memo field.

Railway transshipment dock: a means whereby a railway wagon may be run onto another railway wagon of broader gauge.

Ramp: a steeply graded railway with no evidence of rope haulage.

Road

Rope channel

Ropeway system: one or other of the varieties of aerial transport systems used in the industry.

Ropeway system ceffyl: a surviving example of the transporter carriage from a ropeway.

Ropeway system drum base

Ropeway system tensioning cable

Ropeway system winding engine base: where no structure remains were observed which might once have covered the engine.

Ropeway system winding house

Shaft winding engine house steam: housing for steam engine to power a *haulage shaft*.

Stables

Steps

Strongpoint: a slate- or stone-built structure forming the base of a transport-related device.

Analysis:

The transport requirements of the slate industry have been researched more intensively than any other aspect of their technology, in particular the way in which railways were used, and some of the evidence used in this report derives from excavations made by amateur groups and reported to the Trust.

In nearly all the quarries visited in the course of the survey, internal movement of rubble and of raw blocks was carried out in railed wagons of one sort or another. One exception was Ty'n y Ffridd near Caellwyngrydd where a winding pathway from the face suggested that barrows had been used.¹¹⁴ Since this was one of the Co-operative quarries worked during the strike at Penrhyn from 1900 to 1903, it is quite likely that funds did not extend to rails and wagons. It is possible also that Pen y Ffridd at Llanrhychwyn, (20153) a very early working, never graduated to internal railways, but used barrows or

¹¹⁴ 20063:7.

stretchers, and tip contractors' workings seem nearly always to have depended on barrows or even on carrying the blocks by hand. In neither case are the remains of sufficient interest to warrant protection.

But in the vast majority of cases, even the smallest of quarries were observed to have short runs of narrow gauge railway and a couple of wagons, and sections of rail and fragments of rolling stock are to be found in most abandoned workings.

In open quarries, railways to the working face were often clearly of a temporary character, and little evidence is likely to remain. Adits to provide railway access to underground workings were not only observed in the Blaenau Ffestiniog and Corris districts, but in all regions. As noted in **3.0 Methodology** above, in that the survey did not include underground features, little attempt was made to explore them. In some cases the portals are arched¹¹⁵ but far more commonly they are cut into the rock. Those which have been described as being of national importance have been selected on the basis of their group value.

Rail-types noted were most commonly flat-bottom, standard industrial railway components, sometimes bridge-section and more rarely T-section, sometimes with surviving chairs. Evidence for early or hybrid rail types is rare, but not unknown. A plate-rail was discovered at Cloddfa'r Lon in the spring of 1994, and *Fforwm Plas Tan y Bwlch*, a Ffestiniog-based industrial archaeology group, discovered a length of wooden rail with a wrought-iron strap near the summit of the 4/5 incline at Hafodlas, Bettws y Coed,¹¹⁶ a site developed in the 1860s, which makes it clear that a technology evolved a century earlier on Tyneside was still finding a place at a quarry developed by some of the foremost engineers of the Victorian period. This heightens the value of this particular feature.

If examples of pre-modern rail types are rare, it is nevertheless clear that the slate industry became technically conservative so far as rails were concerned. Rectangular-section wrought-iron bars, of a type common on industrial and contractors' railways in the 1820s, are to be found in some quarries, especially Dinorwic, where much of it is still to be seen on the ground and intact, either in sills or on chairs in stone or wooden sleepers. Scantling timbers were found as longitudinal supports for bridge rail on the Australia to Egypt incline here,¹¹⁷ a technology evolved by Brunel on the Great Western Railway. Stone blocks or sleepers, largely superseded by timber sleepers after the construction of the London and Birmingham in the 1830s, clearly continued to be laid for many years in Welsh slate quarries, and evidently remained in regular use at Dinorwic until 1969. These add very considerable to the value of the area recommended for scheduling. Prince of Wales quarry contains an unusual run of these blocks, designed to accommodate as many as six chairs on the one piece of stone,¹¹⁸ which falls within the suggested area.

A number of distinctive types of rail, apparently unique to the industry, were recorded, such as the "Thomas Hughes" type, which consists of a length of round-section bar bent at each end to fit into a cast-iron sill or into a hole drilled into timber or a stone. These formed a crude but effective railway in places where workings were likely to be extended or developed and the rails might have to be moved regularly. Examples have turned up at Cwm Eigiau on the mill tips and Cefn Du; archival evidence suggests that they were to be found throughout the county.¹¹⁹ The best instance is to be found in the area recommended for scheduling at Gorseddau quarry, in the form of a Thomas Hughes point system, consisting of two large slate blocks with holes drilled in them to allow a set of rails to be moved over bodily to line up with either of the sidings.¹²⁰ Simple rail systems such as these held sway in the

¹¹⁵ E.g. 20457:14.

¹¹⁶ 20156:16.

¹¹⁷ 20091:73.

¹¹⁸ 20221:22.

¹¹⁹ 20100:3, 20490:27, *Caernarfon and Denbigh Herald*, 23.08.1845.

¹²⁰ 20238:25.

industry for many years, and there is little evidence for the use of the standard twentieth-century type of contractors' or industrial railway with pressed steel sleepers, though some survives on Egypt level at Dinorwic.

Another respect in which Gwynedd slate quarries were technically a law unto themselves is in the use of double-flanged wheels loose on the axles. These necessitated the use of stub-points. Examples remain in use at Maenofferen, and they seem to have been well-nigh universal in the northern part of Gwynedd. The surviving length of railway in use at Aberllefenni,¹²¹ however, uses single-flanged wheels but deviates from standard practice by using single-bladed points. These are known from photographic evidence to have been used at neighbouring Braich Goch (20469), and may have been a peculiarly Corris method.¹²²

It is a commonplace that the gauge of a Gwynedd slate quarry railway was slightly less than 2', except for Bryneglwys (2430) and the Corris area, where 2' 3" became the norm, and Cae Abaty and Minllyn, Dinas Mawddwy (20456, 20457) where 2' 4 1/4" is recorded.¹²³ The exit railway at Cwm Ebol (20428) is said to have been 3' gauge for part of the quarry's working life,¹²⁴ but it is not clear from archaeological evidence whether the rails in the quarry itself were to the same gauge. Possibly a similar system existed here to the one at Gorseddau where it is apparent from surviving features that the rails on the galleries and faces were 2' gauge, but that the incline and the railway to the mill at Ynys y Pandy were 3' gauge.¹²⁵ These features fall within the area suggested for scheduling.

A slightly different situation is implied at Pen y Bryn quarry in Nantlle (20037), where internal rails were 2' gauge but the finished products were moved on the 3' 6" Nantlle Railway. A transshipment dock was observed at the foot of the Pen y Bryn exit incline¹²⁶ to allow 2' gauge wagons from Pen y Bryn to be placed bodily on 3' 6" wagons and transported to the Dorothea mill, a method which derives from the Dinorwic Quarry Railway, and which was also followed at Blaenau Ffestiniog by the London and North Western Railway and the Great Western. It is the unique survivor of its kind. The plateway at Diffwys (Casson) (20305) has left evidence in the form of 3' 6" gauge sleepers;¹²⁷ the probability is that such systems were used for the removal of large amounts of traprock, but no examples were noted in the course of the survey.

Motive power for many quarry railways was clearly the quarrymen themselves; two men are needed to propel a wagon of slate rubble. Though the absence of stables from many sites is itself proof of nothing, since horses or stabling could be hired from neighbouring farmers, many surviving wagon bodies have a bar on the closed end to enable them to be pushed and pulled by hand. Some lack drawgear, so they could not run in a train. Though stables were identified at a number of sites, and many others may have existed, it is possible that in some of these cases horses may only have been used only for external transport, either by cart or by railway wagon. Dorothea quarry not only preserves stables for its own horses, but also the "day-stable" for hired horses, emphasising the importance of animal power even on a site that was investing considerable sums of money on new technology.¹²⁸

Occasionally other types of evidence emerge for the use of horses within quarries, such as the sill discovered at Cwm Eigiau,¹²⁹ which has a down-curving cross-bar to avoid ripping up the animal.

¹²¹ 20478:8.

¹²² James Boyd, *On the Welsh Narrow Gauge* (Bradford Barton, n.d.) p. 55.

¹²³ 20456:2.

¹²⁴ Boyd 1970, p. 290.

¹²⁵ 20238:1, 6, 25.

¹²⁶ 20037:2.

¹²⁷ Though these were not observed in the course of the survey, their presence is indicated by Richards 1991, p. 129.

¹²⁸ 20033:19, 22.

¹²⁹ 20100:32.

Rolling stock on internal railways falls into two broad categories, the flat wagon, used for slabs and the open ended wagons used for transporting either blocks split into pallet form or rubble. Flat wagons seem to have been rare in Nantlle, otherwise both types were met with throughout Gwynedd. Local variations are apparent, such as the use of outside frames at Penrhyn, and inside frames elsewhere. In places a number of exit railway wagons were observed, a *wagan dre*¹³⁰ from the Nantlle Railway at Pen y Bryn¹³¹ and some Festiniog Railway wagons, still in long rakes, at Llechwedd.¹³² Many examples survive in museums, and there is little point affording statutory protection to those which survive on site.

Steam locomotives were used in twenty-four of the larger slate quarries from the late 1860s to the late 1960s,¹³³ and have left their mark in a number of ways. In some cases repair facilities survive, including some very comprehensive workshops at Penrhyn, Dinorwic and Pen yr Orsedd. Sheds were found on a number of sites; that on Bonc Brig at Pen yr Orsedd was singled out for recommendation in that it has a low water tank designed for De Winton locomotives, and stands next to a well-preserved weighbridge-house.¹³⁴

Locomotives use altered quarry arrangements in a number of ways. Galleries had to be extended in such a way as to make them strong enough to support locomotives, adits widened to accommodate them, heavier rails installed. At Dinorwic quarry, where much trackwork survives on some of the levels, the locomotive-worked sections are clear from the use of substantial bull-head rail in chairs, derived from standard gauge practice. Cilgwyn quarry in the Nantlle district exemplifies how the use of locomotives could alter tipping practice; instead of the familiar "finger-runs" of rubble, designed to minimise the amount of distance from source to tipping point in hand-tramming, Cilgwyn rubble was disposed of at the end of one of two substantial tips some distance away from the mills, since it owned some powerful locomotives designed to cope with heavy loads. The impressive horse-shoe tip run is not only the most impressive example of such a feature, it is of great importance in demonstrating the close relationship between the Gwynedd slate industry and narrow-gauge technology world-wide, in its use of a sinuous route to gain height.¹³⁵

Lighter internal combustion and battery-electric locomotives provide less archaeological evidence. At Dinorwic a number of what were known as "tractor sheds" survive in the area recommended for scheduling, distinguished from their steam counterparts' facilities by the absence of coal and water facilities and of an inspection pit.¹³⁶ In some other quarries it seems clear that such locos were kept inside the mill buildings, and had no designated sheds of their own. A number of such locomotives themselves survive; at Llechwedd and Maenofferen three elderly Ruston Hornsby diesel locomotives are stored¹³⁷ and Maenofferen still uses one 1936 Wingrove Rogers battery-electric locomotive, as well as two more modern examples.¹³⁸ While they are not suitable for scheduling themselves, it is worth observing that these are the earliest examples of their kind outside a museum. Aberllefenni's one locomotive is of recent manufacture.

¹³⁰ "Town wagon", so called because originally they took the slates to Caernarfon.

¹³¹ 20037:9.

¹³² 20300:42.

¹³³ Bradley, 1992, *passim*.

¹³⁴ 20061:1-14, 20091:132, 20039:29, 56. This last feature has a water-tower built on a low slate plinth, more suited to the deWinton vertical boiler locomotives than to the Hunslet saddle tanks that were also used at Pen yr Orsedd.

¹³⁵ 20034:1-2. The locomotive which operated this tip-run, *Jubilee 1897*, a Manning Wardle 0-4-0 saddle tank, 1382 of 1897, is preserved in the Tywyn museum, a substantial machine capable of exerting a tractive effort of no less than 4580 lbs @ 75% boiler pressure.

¹³⁶ 20091:97.

¹³⁷ 20300:34, 20306:32.

¹³⁸ Wingrove Rogers 918 of 1936.

Though overhead-wire electric locomotives were used at Croesor (20279) and at Llechwedd (20300), the cables and their supports have gone from both sites. The Llechwedd locomotives themselves have been preserved, but of Moses Kellow's original locomotive of 1904, built with parts supplied by Kolben of Prague, nothing remains.

Transport between levels was carried out by a number of different means, depending on whether material had to be raised or lowered. The simplest method observed was a ramp, on which wagons were presumably horse-hauled. Examples were observed at the foot of the Vivian incline system, to reach the first floor of the Gorseddau mill, (scheduled) and on a tip at Bryneglwyns.¹³⁹ For lowering blocks or rubble, the method most commonly employed was the counter-balanced incline, two parallel tracks on a gradient of anything from 1/10, in which the descending load pulled up the empty wagons on a wire-rope passed around either a wooden drum built on a cast-iron frame or a horizontal sheave at the summit. Very many such inclines survive from all over Gwynedd, and in many cases the drum itself, the brake gear, the rope and sometimes the rails survive. The biggest concentration of these are to be seen at Vivian (20087), where they are already scheduled, and Dinorwic (20091), where three are scheduled. With the single exception of the topmost incline at Vivian,¹⁴⁰ all of these were operated by a drum, but within this pattern a considerable number of variations are apparent. At Vivian all the drum inclines have an external brake system, also to be found in one instance at Dinorwic.¹⁴¹ Most of the drumhouses are of the "through" pattern, in which the level rails pass under the drum, but some are of the "remote" type in which the drumhouse does not straddle the rails.¹⁴²

In view of the statutory protection already offered to a number of good examples of this type of technology, there may appear little to recommend scheduling others. However, these features were a vital part of the industry, and took many different forms.

Sheave inclines were less common, and it is not clear what led to the choice of a sheave or drum. A sheave system survives more or less intact, though unfortunately without rails, at Hafodlas, Bettws y Coed,¹⁴³ and poorer examples were found at Goleuwern and Ratgoed.¹⁴⁴

Counter-balanced inclines could serve intermediate levels by pointwork and a level tramway leading off it. Dinorwic contains a number of inclines on this principle outside the scheduled area, but the best examples were observed at Prince of Wales and Gorseddau.¹⁴⁵ These are therefore included in the list below.

One important variation, which Dinorwic and Vivian again exemplify, is between the conventional incline in which wagons ran on their own rails and the *trwnc*, "table" or "transporter" incline, in which they were carried, often several at a time, on a transporter (*trwnc* in Welsh) which kept them on a level plane. The transporter gauge was generally considerably greater than 2'; that on Australia level at Dinorwic¹⁴⁶ is in the order of 5' 6", though it has degraded slightly. It is a more complete survival than those at Vivian which are already scheduled, and has an unusual underground drum-housing with a ship's wheel control. The transporter incline was useful on steep gradients,¹⁴⁷ and offered certain advantages where there were intermediate levels, where the transporter could be halted part-way up or

¹³⁹ 20087:12, 20238:58, 20430:41.

¹⁴⁰ 20087:64.

¹⁴¹ 20091:28.

¹⁴² E.g. 20091:15, 28, 58.

¹⁴³ 20156:17.

¹⁴⁴ 20367:19 (sheave *in situ*), 20489:23 (site only)

¹⁴⁵ 20221:10-13, 25, 20238:49, 51-53.

¹⁴⁶ 20091:73.

¹⁴⁷ 20487:10.

down and the wagon wheeled off onto a dock.¹⁴⁸ These docks, and the docks at the foot of the incline which accommodated the *trynciau*, are often the only evidence that the incline was of this form.

A variation on the counterbalanced incline only met with at Dinorwic was the "lift", effectively a form of *trwnc* incline so steep that the *trynciau* themselves resembled colliery cages, and the 2' gauge wagons were carried within them rather than on them.¹⁴⁹

Uphaulage from pits or mines was a more complicated matter, and whilst both conventional and *trwnc* inclines were used, powered rather than counterbalanced, various other methods were also observed.

Doubtless in the very early days of the industry turntrees or in Welsh *chwimsis* were employed, but these structures have left no trace. Only at two places have horse whims been identified, at Hendre near Dolwyddelen and (a slightly poorer example) Foel near Capel Curig.¹⁵⁰ In all probability these lifted only the blocks of slate, not the wagons as well.

Powered inclines were commonly used in the mines of Blaenau Ffestiniog and the southern part of Gwynedd generally. The simplest form was the water-balance, which was also used for tipping mill-waste in restricted locations, and particularly good examples built for this purpose survive at Aberllefenni.¹⁵¹ Here, the material is raised by the superior weight of a tank on a parallel track which is filled with water at the top of the incline and emptied at the bottom. An alternative use of water-power for uphaulage is to be found at Cwm Machno, where a water-wheel powered an incline.¹⁵² This particular example has gone through several stages of re-use, and functioned also as a water-balance and a counter-balance, an excellent illustration of the way in which transport structures in particular had to be adapted to meet different quarry needs. The better example from Aberllefenni and the Cwm Machno system both exemplify these important forms of hydraulic technology.

The sites of steam winding engines are met on a considerable number of Blaenau inclines, and it is possible that they superseded water-balance systems in some cases. Only at Cwt y Bugail do substantial remains survive; the boiler, firebox, smoke box and parts of the control mechanism for a steam winding engine survive at the summit of a tip incline together with part of the drum axle.¹⁵³ The remains of a four-track uphaulage incline survive at Oakeley¹⁵⁴ and a three-track uphaulage incline is still operated at Maenofferen.¹⁵⁵ Though only one set of rails remains in use and the original steam engine has been replaced by an electric motor dating from 1900, it is a remarkable survival, and is offered as a candidate for listing. Other inclines remain in use underground at Maenofferen, which might also be felt to merit listing, though they did not form part of the survey.

Rhiwbach quarry in Cwm Penmachno made use of a remarkable and ingenious system whereby the one steam engine powered the first incline on the exit railway to Blaenau, a shaft, and two uphaulage inclines from lower parts of the site, as well as the main mill.¹⁵⁶ Later an electric motor did duty. This forms part of the area recommended for listing at Rhiwbach, as best exemplifying the diversity of uses to which a single power-source could be put. The exit incline here is the better example of an uphaulage exit railway incline within Gwynedd.

¹⁴⁸ E.g. 20468:20, 23, 25,

¹⁴⁹ 20091:21, 22, 31, 32.

¹⁵⁰ 20097:21, 20105:23.

¹⁵¹ 20497:9, 18.

¹⁵² 20132:28-30.

¹⁵³ 20311:41.

¹⁵⁴ 20296:54-55.

¹⁵⁵ 20306:17.

¹⁵⁶ 20313:1-6, 24, 28.

Electricity commonly replaced steam at Blaenau Ffestiniog for uphaulage; the *inclin bon* drumhouse at Llechwedd best demonstrates the way in which these structures were re-adapted, in that the base for the steam engine and the crank are still evident.¹⁵⁷ Of the extensive electrification programme carried out at Oakeley quarry, only the incline which leads up to the Gloddfa Ganol Mountain Tourist Centre retains rails and electric motor, and this only as a result of a deliberate restoration project after it had been initially dismantled.¹⁵⁸

Internal combustion was certainly used to power uphaulage inclines, but remains were met at only one site, and appear to be very late. At Cwt y Bugail, parts of an old petrol locomotive operated an incline by means of a barrage-balloon winch. The Heath-Robinson appearance of this contraption appears to confirm anecdotal evidence that petrol motors were generally only used on inclines in poorly-capitalised concerns.¹⁵⁹

Uphaulage inclines were certainly used elsewhere in the industry; remains are evident at Glynrhonwy Upper and Glanrafon,¹⁶⁰ but in Nantlle, the other major quarrying district where processing had mostly to be carried out at a higher level than extraction, only at Cilgwyn are any remains evident,¹⁶¹ and they are of poor quality.

A more common uphaulage method in the Arfon quarries involved a ropeway of one sort or another. The earliest type, which involved a rope stretched across the pit from which another rope depended at one end whilst its other end was wound round a drum powered by a horse whim, is known only from a painting by John Smith of one of the Glynrhonwy quarries in the National Gallery of Wales. It has left no trace.

The earliest type of ropeway of which archaeological evidence survives is the chain-incline, in which a continuous rope or chain is attached to a fixed point at the quarry pit and to a drum on a strongpoint on the bank. By rotating the drum, wagons attached to the rope or chain may be raised or lowered. Unique evidence for such a system survives, complete with attendant wheelpits, at Bryneglwys quarry near Abergynolwyn,¹⁶² where the system was introduced by John Lloyd Jones of Dorothea quarry in Nantlle in the 1860s. At Nantlle itself, the strongpoints at Dorothea,¹⁶³ already scheduled, exemplify the next stage of the typology, with more sophisticated headgear and steam-power.

The final development of the ropeway in the Arfon quarries is the "blondin" (named after Charles Blondin, who crossed Niagara on a tightrope in 1859), developed in the Aberdeen granite quarries and also to be found in the slate quarries of Cornwall and Argyll.¹⁶⁴ The versions observed at Dinorwic quarry are inclined¹⁶⁵ but the evidence from Nantlle indicates a rope running from a timber or steel mast, spanning the pit. In each case, hoisting is mounted on a travelling carriage (in Welsh *ceffyl*, "horse") running on the rope and controlled from the bank. Evidence for them is to be found at a number of sites. One of the most impressive is at Pen y Bryn, where the size of the winding-engine house suggests that an engine on the scale of a colliery winder was installed.¹⁶⁶ Considerable remains of a smaller system, including a steam winding engine by J.M. Henderson and Co. of Aberdeen, survive at

¹⁵⁷ 20300:28.

¹⁵⁸ 20296:58, 59.

¹⁵⁹ 20311:35. An example of such a device, unfortunately no longer in existence, constructed in similar circumstances is the ropeway winding engine built by Levi Jones, barracks Tan yr Allt, by jacking up a Morris Minor and attaching a drum to the brake.

¹⁶⁰ 20073:12, 14, 52, 20196:26, 27, 41.

¹⁶¹ 20034:6.

¹⁶² 20430:33-37.

¹⁶³ 20033:7, 26.

¹⁶⁴ Sir C. LeNeve Foster, Professor R. Herbert Cox, *Ore and Stone Mining* (Charles Griffith, London, 1910) pp. 431-4.

¹⁶⁵ 20091:53-54, 112-115, 126.

¹⁶⁶ 20036:34.

Blaen y Cae¹⁶⁷ and three complete systems are to be found at Pen yr Orsedd, complete with the Bruce Peebles electric motors which latterly powered them, as well as traces of the mounting-beds for the steam-engines which were used initially.¹⁶⁸ Of particular interest here are the systems of pulleys which take the ropes from the winding-engine houses to the masts; since the masts had to be repositioned as quarrying advanced, but winding engines tended to remain where they had been installed, the ropes often had to pass through several 90° turns. These features are scheduled in their entirety.

The blondin, like the chain incline, is practically unknown outside Arfon; possibly the overhead ropeway used to tip rubble at Llechwedd may have been of this pattern, but archaeological confirmation is lacking.¹⁶⁹ Only at Rhos, Capel Curig, is there clear evidence for such a system, waterwheel-powered, but nevertheless clearly very late.¹⁷⁰ It is significant not only because it demonstrates a small quarry's dependence on water power but also as an example of a small-scale twentieth-century system.

One other uphaulage system deserves mention, the shaft. Two water-balance headframes are believed to survive at Penrhyn quarry, of a type broadly similar to those found in the Glamorgan coalfield in the nineteenth century. This site could not be visited, but they might be of international significance if they survive substantially complete. A shaft at Pen yr Orsedd¹⁷¹ is topped by a dilapidated slate structure, which may be the base for a water-balance, and a shaft which was water-balance operated remains at Oakeley quarry, though without any head-gear or other archaeological evidence of how it functioned.¹⁷² Only at two sites have colliery-style steam winding-engine houses been found in conjunction with uphaulage shafts, at Ty Mawr East in Dyffryn Nantlle, where the shaft itself has recently been filled in and at Tan y Bwlch, near Bethesda, where the engine house survives complete with timber crank bases as part of a private residence, and the shaft is still open.¹⁷³ Electrically- or internal combustion engine-operated shafts appear to have been unknown.

Wherever levels needed to cross each other, the most common form of bridge involved slate-waste abutments with a timber deck, which in most cases has vanished. A number of examples are to be found at Prince of Wales and Gorseddau within the recommended areas.¹⁷⁴

The most spectacular of these structures has been largely demolished; at Oakeley quarry only the pillars remain of the Welsh Slate Company's viaduct over the Afon Barlwyd.¹⁷⁵ Nevertheless, it is an impressive feature.

The other form of a bridge is an all-stone structure with a corbelled arch; attractive examples survive at Bryn Hafod y Wern¹⁷⁶ and Goleuwern.¹⁷⁷ Possibly the "wailing wall" at Gorseddau, the long stone structure on the approach to the quarry which holds back the tip, was the first stage in constructing a "cut and cover" corbelled tunnel across the exit railway to allow the tip to be extended.¹⁷⁸

Though exit railways did not form part of the survey once they had left the quarry precincts, loading bays where slate was transferred from the quarry's internal railway network to an external transport system were included. At Wrysgan slates were evidently loaded from the quarry's wagons to packhorses

¹⁶⁷ 20031:17-24.

¹⁶⁸ 20039:51-55.

¹⁶⁹ 20300:52.

¹⁷⁰ 20110:18, 19, 39.

¹⁷¹ 20039:63.

¹⁷² 20296:6.

¹⁷³ 20030:1-3, 20062:17-20.

¹⁷⁴ 20221:27, 20238:22, 29, 49.

¹⁷⁵ 20296:???

¹⁷⁶ 20296:65.

¹⁷⁷ 20367:31.

¹⁷⁸ 20238:1

at Cei mulod, though little survives here.¹⁷⁹ The fullest survival, and the most typical of the arrangements that prevailed in a number of quarries at one time, is Llechwedd quarry's Pant yr Afon wharf, where sidings branched off the foot of the incline that connected the quarry with the Festiniog Railway to give access to the London and North Western Railway.¹⁸⁰

Finally, as well as movement of the slate, provision had also to be made for the quarrymen to reach their workplace. Steps are scheduled at Vivian¹⁸¹ and other steps fall within the areas outlined at Pen yr Orsedd and Dinorwic.¹⁸²

The following in this class are already scheduled:

20087	VIVIAN	27	ADIT
20091	DINORWIC	143	BRIDGE
20033	DOROTHEA	2	DOUBLE ARCH
20087	VIVIAN	24	DRUMHOUSE THROUGH
20087	VIVIAN	46	DRUMHOUSE THROUGH
20087	VIVIAN	61	DRUMHOUSE THROUGH
20087	VIVIAN	23	INCLINE COUNTERBALANCE
20087	VIVIAN	31	INCLINE COUNTERBALANCE
20087	VIVIAN	39	INCLINE COUNTERBALANCE
20087	VIVIAN	45	INCLINE COUNTERBALANCE
20087	VIVIAN	55	INCLINE COUNTERBALANCE
20087	VIVIAN	64	INCLINE COUNTERBALANCE
20091	DINORWIC	138	INCLINE COUNTERBALANCE
20091	DINORWIC	140	INCLINE COUNTERBALANCE
20091	DINORWIC	146	INCLINE COUNTERBALANCE
20087	VIVIAN	32	INCLINE DRUMHOUSE THROUGH
20087	VIVIAN	40	INCLINE DRUMHOUSE THROUGH
20091	DINORWIC	139	INCLINE DRUMHOUSE THROUGH
20091	DINORWIC	147	INCLINE DRUMHOUSE THROUGH
20087	VIVIAN	56	INCLINE INTERMEDIATE LEVEL
20087	VIVIAN	65	INCLINE SHEAVE
20087	VIVIAN	22	INCLINE TRWNC DOCK
20087	VIVIAN	30	INCLINE TRWNC DOCK
20087	VIVIAN	38	INCLINE TRWNC DOCK
20087	VIVIAN	44	INCLINE TRWNC DOCK
20033	DOROTHEA	5	INCLINE UPHAULAGE MECHANICAL
20033	DOROTHEA	41	LOCOMOTIVE SHED
20033	DOROTHEA	25	LOCOMOTIVE SHED
20091	DINORWIC	135	LOCOMOTIVE SHED
20033	DOROTHEA	1	RAILWAY
20087	VIVIAN	66	RAILWAY
20238	GORSEDDAU	59	RAILWAY
20087	VIVIAN	47	RAILWAY EQUIPMENT
20238	GORSEDDAU	58	RAMP
20033	DOROTHEA	7	ROPEWAY SYSTEM
20033	DOROTHEA	26	ROPEWAY SYSTEM
20039	PEN YR ORSEDD	51	ROPEWAY SYSTEM
20039	PEN YR ORSEDD	52	ROPEWAY SYSTEM
20039	PEN YR ORSEDD	53	ROPEWAY SYSTEM
20033	DOROTHEA	27	ROPEWAY SYSTEM WINDING HOUSE

¹⁷⁹ *i.e.* "the mule wharf"; 20289:2.

¹⁸⁰ 20300:2-15.

¹⁸¹ 20087:10.

¹⁸² 20039:28, 40, 20091:76, 131.

20033	DOROTHEA	35	ROPEWAY SYSTEM WINDING HOUSE
20033	DOROTHEA	36	ROPEWAY SYSTEM WINDING HOUSE
20039	PEN YR ORSEDD	54	ROPEWAY SYSTEM WINDING HOUSE
20039	PEN YR ORSEDD	55	ROPEWAY SYSTEM WINDING HOUSE
20039	PEN YR ORSEDD	66	ROPEWAY SYSTEM WINDING HOUSE
20087	VIVIAN	29	STEPS

5.5 Structural features

Summary:

A number of features were identified which belong to no obvious category.

Terminology:

This category includes:

Double arch
 Mine adit metalliferous
 Mine tip metalliferous
 Obliterated
 Retaining walls
 Structure
 Wall

Analysis:

A feature of the industry throughout Gwynedd is the use of slate rubble to form retaining walls to hold back the tips wherever space was scarce, or to support a transport system. Particularly impressive examples of the former are to be found at Gallt y Fedw in Dyffryn Nantlle,¹⁸³ and at Dinorwic,¹⁸⁴ both recommended for scheduling.

One unusual related feature is the attractive double arch at Dorothea quarry over the course of the siding connecting the working bank to the Nantlle Railway, designed to keep the two retaining walls in place under the weight of the slate rubble.¹⁸⁵ This feature already forms part of the scheduled area of the quarry.

At three sites evidence of metalliferous mining was found. This was invariably small-scale, but exemplifies the point that extractive industries often began looking for one mineral and came across another. None was considered of any particular significance.

A number of features were seen which defied analysis. Wherever possible, a suggestion is made in the memo field of the database, but in many cases the feature was too badly ruined to make this possible. These are therefore included for completeness' sake, and a number necessarily fall within the areas recommended for scheduling. Similarly, there are many instances of areas which clearly formed part of the quarry having been completely obliterated. These are included in order to illustrate the extent to which the archaeological resource has been damaged.

Walls are so described if it seems probable that they were built as such rather than being the remains of a larger structure.

¹⁸³ 20032:2, 13, 14.

¹⁸⁴ E.g. 20091:96.

¹⁸⁵ 20033:2.

The following within this class are already scheduled:

20087	VIVIAN	28	RETAINING WALL
20087	VIVIAN	60	RETAINING WALL
20033	DOROTHEA	3	0STRUCTURE
20087	VIVIAN	33	STRUCTURE
20087	VIVIAN	62	STRUCTURE

5.6. Administration

Summary:

The organisation of most slate quarries in the nineteenth century, whereby the men in a particular bargain contracted with the management to work a particular area of rock, and labourers and badrockmen were paid by the ton removed, meant that it was in the interest of both parties to keep a careful record of work done.

Terminology:

This category includes:

Office

Stackyard

Weighbridge house: a building to house a weighing machine. Where this survives, it is noted in the memo field.

Weighbridge pit: where only the pit was noted, either because the building has vanished or because the machine stood in the open air.

Analysis:

Offices were the buildings where visitors, customers and representatives called, and sometimes an effort was made to apply some decoration to them, perhaps in the form of slate cladding on the external walls or a patterned roof. In some places they also served to remind the quarryman of his hours of work, such as the attractive little bell-house at Aberllefenni,¹⁸⁶ or, at the other end of the scale, the huge workshop-office complex (*y Iard*) at Gilfach Ddu serving Dinorwic quarry, with its diamond-shaped clock-face.¹⁸⁷ Despite the differences in size, it may be that both were intended to emphasise to the traditionally independent quarryman the importance of factory-style discipline and timekeeping. The first example has been recommended for listing, and the second has already been scheduled. A number of other examples appear in the list within the areas considered to be of national importance because of their group value.

In the main, however, there is little evidence for lavish offices and administrative centres at the quarries themselves, often because their functions were divided up with another office at the shipping port. The overall administration of Penrhyn quarry (20061), for instance, was carried out at Port Penrhyn, and of Bryneglwys (20430) at Towyn wharf station.

At all but the smallest quarries weighbridge houses are commonly met on all levels. Occasionally only the pits survive, suggesting that wooden structures covered the machinery. A complete example, still

¹⁸⁶ 20487:4.

¹⁸⁷ 20091:132.

with the lengths of rail on either side of it, survives on Bone Brig at Pen yr Orsedd.¹⁸⁸ Its value is further enhanced by its proximity to a locomotive shed, and it therefore appears in the list.

The fact that slates were offered for sale in different sizes and qualities, and that often output had to be stockpiled, meant that stackyards in some quarries covered a large area.¹⁸⁹ Two examples at Gorseddau fall into the area considered of national importance.¹⁹⁰

Many of the features normally associated with mining are absent from underground quarries; there are, for example, no instances of lamp-rooms, since the men relied on candles for their illumination underground until after the second world war, and jealously guarded their right to buy them themselves.

5.7. Ancillary

Summary:

The work of a slate-quarry required the skills of other skilled manual workers, such as carpenters, foundrymen, fitters, masons, platelayers. This section discusses the facilities of which they made use.

Terminology:

This category includes:

- Blast shelter
- Detonator house
- Foundry
- Magazine
- Shelter
- Smithy
- Store
- Workshop
- Yard

Analysis:

Blast shelters were encountered at only six sites, though it is quite possible that some badly dilapidated buildings elsewhere fell into this category. Those at Vivian quarry have already been scheduled¹⁹¹ and those identified at Dinorwic, Prince of Wales and Gorseddau come within the areas on those sites considered to be of national importance.¹⁹² The paucity of these features may be connected with the fact that black powder was used in such a way as to create only a small explosion.

Only thirteen magazines were identified, nearly all of them windowless buildings, sometimes with 3' thick walls rather than the normal 2'. The outstanding survival is at Hafodlas, which is practically intact, though the wooden shelves have gone.¹⁹³ At Dorothea a detonator house survives as part of the remarkable complex of buildings on the main bank.¹⁹⁴

¹⁸⁸ 20039:57.

¹⁸⁹ E.g. Cefn Du, 20490:28.

¹⁹⁰ 20238:28, 33.

¹⁹¹ 20087:37, 43, 50, 54, 59, 63.

¹⁹² 20091:60, 20221:23, 20238:11, 19, 20, 31, 34, 41.

¹⁹³ 20156:23.

¹⁹⁴ 20033:18.

The most commonly met ancillary structure in a slate-quarry, even the smallest, is a smithy, recognisable by its large hearths. Even a medium-sized quarry might have more than one, such as Rhos quarry, where no less than three were identified.¹⁹⁵ These are considered to be of national importance. However, a number of other smithies are included in **Appendix 1** on account of their group value with other features.

Larger-scale workshop buildings are comparatively rare. At Croesor quarry the ruins of a workshop were noted¹⁹⁶ but this, far from serving the quarry itself, was the site of the "Keldril" manufactory, where Moses Kellow, the manager, produced his unsuccessful hydraulic turbine drill. At Pen yr Orsedd the main workshops survive, partly in the form of an early twentieth century corrugated-iron building (of great interest in its own right) encased in slate walls, containing an overhead gantry crane, a locomotive turntable, a traveller carriage for a ropeway, a lathe, a hearth and other tools.¹⁹⁷ The feature is deteriorating rapidly, and is of very considerable importance. The set-up at Penrhyn quarry's Coed y Parc site is more elaborate, but since it is in re-use, less remains *in situ*. The locomotive sheds and repair facilities survive largely intact, with rails and inspection pits, as does the former quarry foundry, housed in a distinctive tall building with a large doorway. A gantry crane survives nearby.¹⁹⁸ This forms part of an area that could be suitable for listing in its entirety.

Both these sites pale compared to Dinorwic quarry's scheduled Gilfach Ddu workshop,¹⁹⁹ already mentioned above in the analysis of features relating to the administration of the quarries. It is comprehensive purpose-built site without parallel in the industry - indeed, would be hard to find a parallel anywhere else - which includes a carpenter's workshop, a foundry and pattern shop, locomotive repair facilities, a painters' workshop, and a slate mill. Its present guise, as Amgueddfa Lechi, has not altered its character, and many of its original machines remain in use. Nearby is a small enclosed yard, again already scheduled.²⁰⁰

The following in this class are already scheduled:

20087	VIVIAN	37	BLAST SHELTER
20087	VIVIAN	43	BLAST SHELTER
20087	VIVIAN	50	BLAST SHELTER
20087	VIVIAN	54	BLAST SHELTER
20087	VIVIAN	59	BLAST SHELTER
20087	VIVIAN	63	BLAST SHELTER
20087	VIVIAN	51	SHELTER
20091	DINORWIC	132	WORKSHOPS
20091	DINORWIC	134	YARD

5.8. Domestic

Summary:

¹⁹⁵ 20110:5, 6, 29.

¹⁹⁶ 20279:7.

¹⁹⁷ 20039:29.

¹⁹⁸ 20061:14.

¹⁹⁹ 20091:132.

²⁰⁰ 20091:134.

The remoteness of many sites obliged managers and men to provide accommodation, either in the form of barracks or housing for families. The *caban*, the shelter where the men messed together at lunchtime, is a common feature on many sites.

Terminology:

This category includes:

Barracks

Caban

Chapel

Church

Domestic fragments

Drying rooms

Dwellings

Hospital

Privy

Analysis:

A number of different types of structure survive on many sites that relate to the men's domestic and eating arrangements.

The most common single facility to ease the lot of the quarryman was the *caban*, a simple building where the men foregathered for meals. There is often a fireplace, and alcoves where teapots and mugs could be kept. Central eating places seem to have been unknown, and the *cabannau* could only accommodate a small number of men. One instance was found of a *caban* where some attempt had been made at architectural decoration, at Rhos, where the feature is also considered of national importance owing to its group value with the mill and hydraulic system.²⁰¹ Elsewhere *cabannau* are included within areas of particular quarries that are considered of national importance.

Privies, other than those related to barracks, are not particularly common - at Pen yr Orsedd, for instance, a quarry where the management seems to have interested itself in the men's well-being, only two were recorded.²⁰² Elsewhere, as well as purpose-built lavatories, it is known that mill-races were set aside. Again, a number appear on the list below as being integral features of areas of importance.

Pen yr Orsedd also provided a drying-room for the men's clothes, which survives complete with boiler and drying rack²⁰³ which is included as a better survival than the existing scheduled example at Dorothea.²⁰⁴ But generally throughout the industry there was remarkably little provision for the men's cleanliness and comfort - nothing remotely comparable to the pit-head baths to be found at collieries from the first world war onwards, and it is clear that for many quarrymen the long walk or train journey home must have been a cold and uncomfortable experience. Part of this may be ascribed to the reluctance of owners and management to spend money on non-productive work, but part of it may also be due to the quarrymen's traditional, or growing, distrust of paternalism.

At a number of sites dwellings almost amounting to small villages were met, as at the Oakeley quarry at Blaenau Ffestiniog.²⁰⁵ This may possibly be a consequence of Oakeley quarry coming about as an

²⁰¹ 20110:28.

²⁰² 20039:14, 27.

²⁰³ 20039:44.

²⁰⁴ 20033:39.

²⁰⁵ 20296: 34, 41, 45, 47, 49, 52.

amalgamation of three originally separate workings, and the surviving houses are all that remains of a community that grew up cheek-by-jowl with the quarries. At Rhiwbach quarry to the east are to be seen the considerable remains of the remarkable quarry village, a nucleated community which included a shop and a schoolroom,²⁰⁶ which is suggested as being of national importance. Mention should be made in this context of the village of Treforys, named after Richard Morris Griffith of Gorseddau quarry, in Cwm Ystradllyn, with its three rows of *croglloffydd*, next to the manager's house, now completely ruined, with its protective bank of trees.

In a number of quarries barracks were built on or near site for workmen who wished to lodge either permanently or Monday to Saturday. Examples have been identified (and scheduled) at Dinorwic²⁰⁷ but not at Penrhyn. There are none identifiable as such in Dyffryn Nantlle, perhaps because the villages of Llanllyfni, Pen y Groes, Tal y Sarn and Nantlle itself could absorb a number of lodgers. Otherwise, barracks were generally found on the more remote sites. Fragments of brass bedsteads, both double and single, were sometimes found in the ruins in the course of the survey, but it is clear that they offered little else in the way of comfort. Glanrafon quarry, though within easy walking distance of Rhyd Ddu and Waunfawr, had a barracks,²⁰⁸ which is the only known Gwynedd example of a "dual row", a type of dwelling built into a slope in which entry to the ground floor is from one side of the row and entry to an independent sets of rooms on the first floor is from the other side. This is therefore considered of national importance, as are the barracks at Rhos and Prince of Wales, for their group value with other structures.²⁰⁹

In contrast to accommodation for the quarrymen, which was rarely anything other than bleak and functional, housing for managers and other senior employees could be imposing, and was clearly meant to reflect their senior status, though it is equally clear that they were also expected to live near the quarry itself. They are for the most part conventional Victorian Welsh middle-class dwellings, often shaded by trees to confer some privacy, for instance "Quarrybank", the Votty and Bowydd manager's house.²¹⁰ The best example of these types of houses was considered to be the example at Parc, where the walls are hung with slate cladding, presumably as much to advertise the quarry's output was to protect the structure of the house. It is still inhabited.²¹¹

There was little evidence on any of the sites where dwellings were found of any sort of community infrastructure. At Ratgoed a chapel stands near the lower mill,²¹² and at Tal y Sarn a church was found to have been converted into offices,²¹³ one of a remarkable group of functional buildings and dwellings sandwiched between the old road and the course of the Nantlle Railway. However, neither on site nor in any of the neighbouring villages was there found anything remotely equivalent to the miners' institutes which were to be found in the north-east Wales coalfield as well as in Glamorgan. Though the quarrymen's formal debates in the *caban* during the lunchtime meetings on politics and current events are a matter of record, and though owners, managers and officials might encourage involvement in recreational activities like silver bands, it appears that the chapels and the church continued to dominate the free time of the quarrymen and their families, that denominational allegiances remained strong, and that secularism made little impact.

The following in this class are already scheduled:

20087	VIVIAN	26	CABAN
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²⁰⁶ 20313:57.

²⁰⁷ The "Anglesey barracks", 20091:145.

²⁰⁸ 20196:5.

²⁰⁹ 20110:4, 20221:45.

²¹⁰ 20303:35.

²¹¹ 20259:1.

²¹² 20489:46.

²¹³ 20025:35.

20087	VIVIAN	35	CABAN
20087	VIVIAN	48	CABAN
20033	DOROTHEA	39	DRYING ROOM
20087	VIVIAN	34	PRIVY

6.0 Summary

In all 106 quarries were selected for visiting out of a total of 464. A total of 2,731 features were recorded, of which eighty-one are scheduled. The results of the survey are presented in Appendix 1, which contains a map of each quarry showing the features recorded, and a list of each of the features.

7.0 Addendum

It was not possible to visit Penrhyn slate quarry as part of the preparation of the foregoing report, but the site was visited in August 1995 whilst carrying out an archaeological assessment for Penrhyn Quarry. In the light of the information gathered in the preparation of this document, only two features at the quarry were felt to be of particular archaeological merit. These are the two water balance shafts mentioned in [5.4] **Analysis** above. They are remarkable survivals, both in fundamentally good condition, one preserved near the main office, the other in slightly poorer condition on a lower level (Ponc Sling). The shafts themselves are intact, and the balance headgear in both cases is practically complete, as are the cages. A number of other shafts survive, though the machinery has gone.

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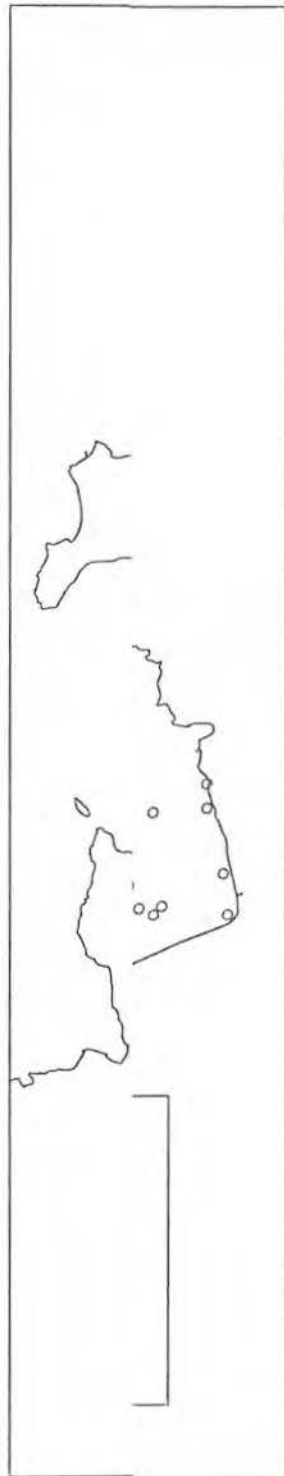
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- RICHARDS R 1868 *POEMS AND SKETCHES*
- RICHARDS W M 1933 *GENERAL SURVEY OF THE SLATE INDUSTRY*
- ROBERTS D 1986 TECHNOLEG DRADDODIADOL YNG NGILFACH DDU *TCIS* 47
- ROBERTS D 1982 MOSES KELLOW A CHWARELI CWM CROESOR *TMIS* IX 2
- ROBERTS O 1886 *CHWEDLEUON MACHNO*
- ROOSE WILLIAMS J *QUARRYMAN'S CHAMPION*
- SKINNER *SKINNERS MANUAL*
- SOMERS A J *CHWAREL Y DIFFWYS*
- STYLES S 1974 *SLATE CAVERNS - OLD LLANFAIR QUARRY GUIDE*
- THOMAS JOHN *JOHN THOMAS COLL.*
- TOMOS D 1980 *LLECHI LLEU*
- TURNER LL 1903 *MEMORIES*
- TURNER S 1974 *THE PENRHYN AND PADARN RAILWAYS*
- WEAVER R 1990 THE OAKELEY BS90S *FFESTINIOG RAILWAY HERITAGE GROUP JOURNAL* 23
- WEAVER R *THOUGHTS ON SAWS*
- WILLIAMS D 1986 *CHWARELI A CHLODDFEYDD YN Y PENNANT*
- WILLIAMS G J 1882 *IIANES PLWYF FFESTINIOG*
- WILLIAMS J A 1962 *TREM YN OL*
- WILLIAMS J LL & JENKINS D A 1993 DWR A LLECHI YM MIILWYF LLANLLECHID *TCIS* 54
- WILLIAMS M C 1991 *THE SLATE INDUSTRY*
- WILLIAMS-ELLIS M I 1928 ELECTRIC TRACTION AS APPLIED TO QUARRIES AND MINES *QUARRY MANAGERS JOURNAL*





Mills were generally functional buildings. This example at Minllyn, near Dinas Mawddwy, was built pre-1845, and was the first in the county to make use of steam power.



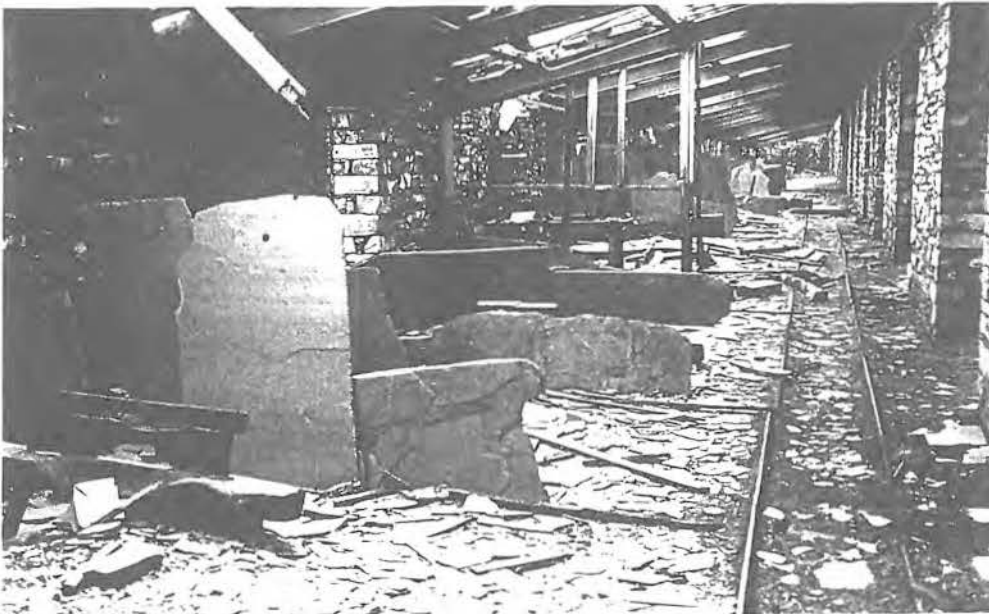
Hafodlas quarry was extensively mechanised in the 1860s. The gantry crane survives, and bases for the Hunter patent saw are visible.



The no. 3 mill at Rhosydd quarry dates from the 1850s, when many of the mines working Ordovician slate began to mechanise.



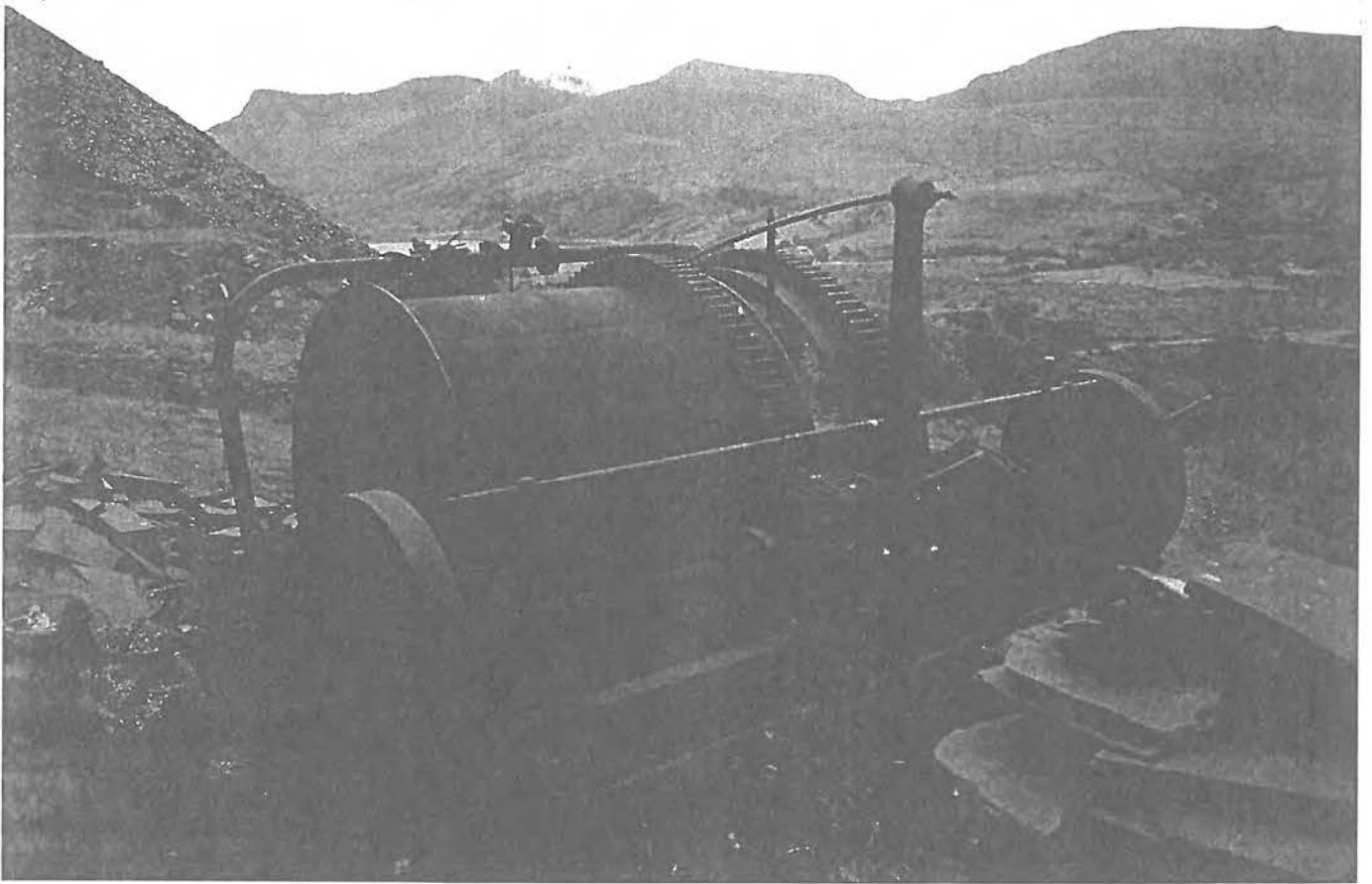
Rhos quarry's mill is a blend of the old and the new. The larger trusses cover a machine area, but to the left are the traditional shelters where individual quarrymen split the slates.



Even in the 1920s when Australia mill was built at Dinorwic, slates were still being dressed by hand. On the left is an example of the trafal, on which the slate was placed to be square-trimmed with a knife.



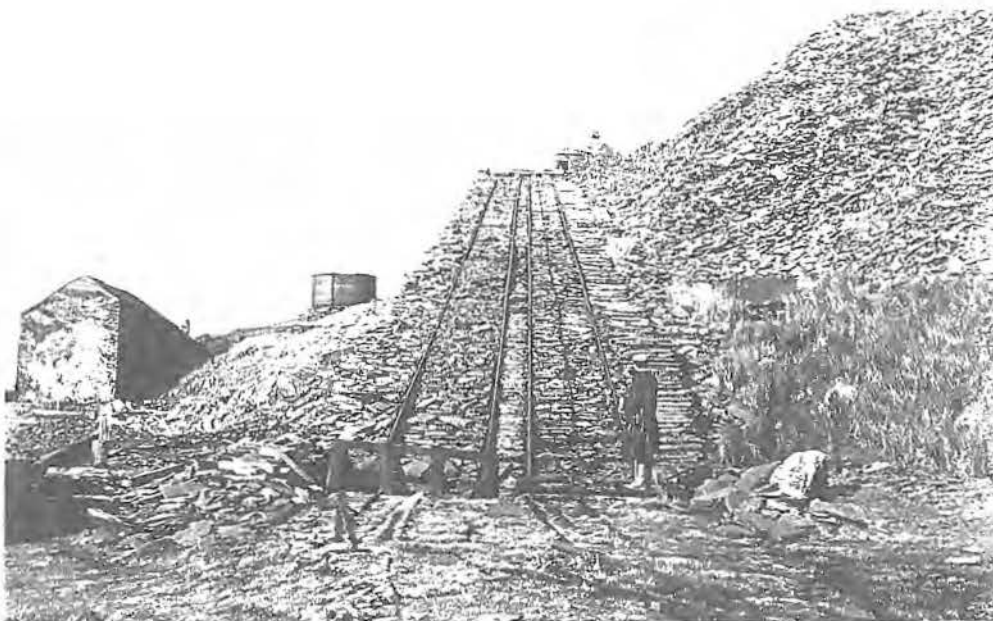
Steam-powered haulage shafts on the lines of a colliery were rare in Gwynedd slate quarries. Nevertheless, the remains of such a system survive at Ty Mawr East in Dyffryn Nantlle.



The steam winder at Blaen y Cae, which operated a ropeway system to haul rock from the pit.



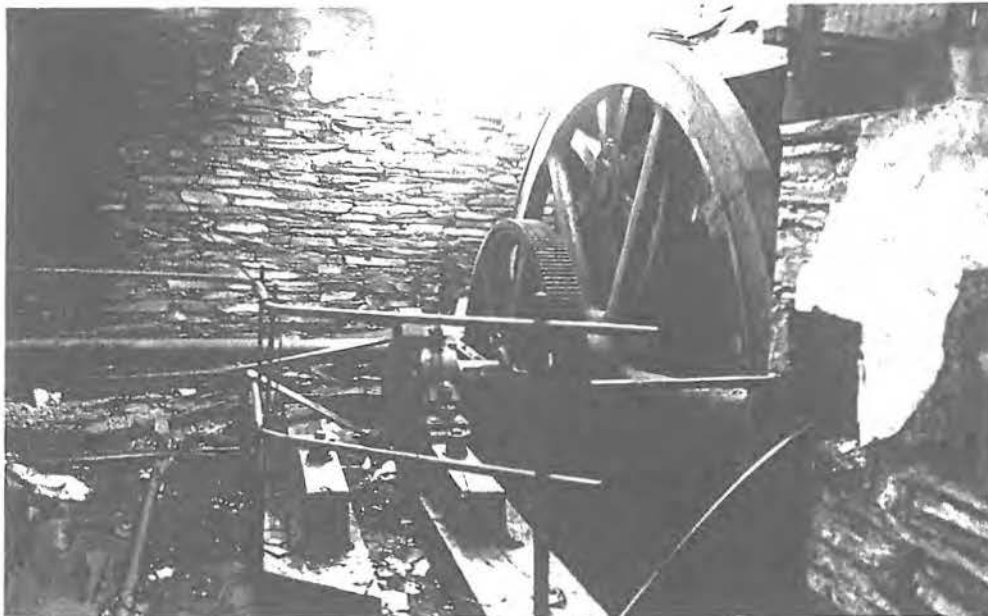
This strongpoint at Cwm Machno quarry supported the summit of a water-balance incline.



Where the quarry workings lay above the processing site, a counter-balance incline overcame the difference in levels. This example survives intact at Dinorwic quarry.



The slate industry made great use of water-power, and waterwheels remained in operation on some upland quarries to the end. This example at Rhos was built as late as 1934.



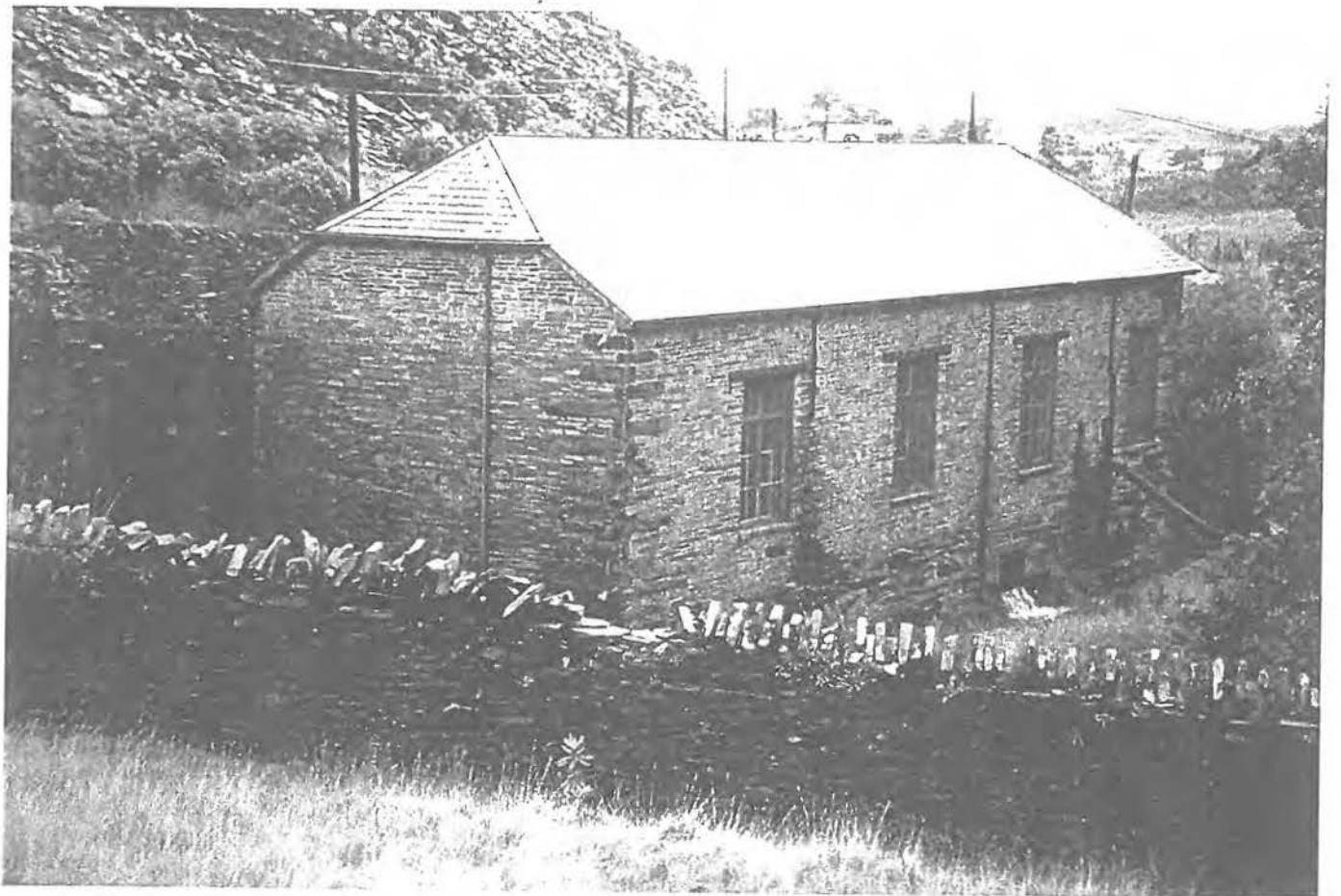
Steam and electricity have both powered this winding machinery at Llechwedd, which remained in use until the 1970s. The cylinder block base is seen in the foreground, with the crank still in place.



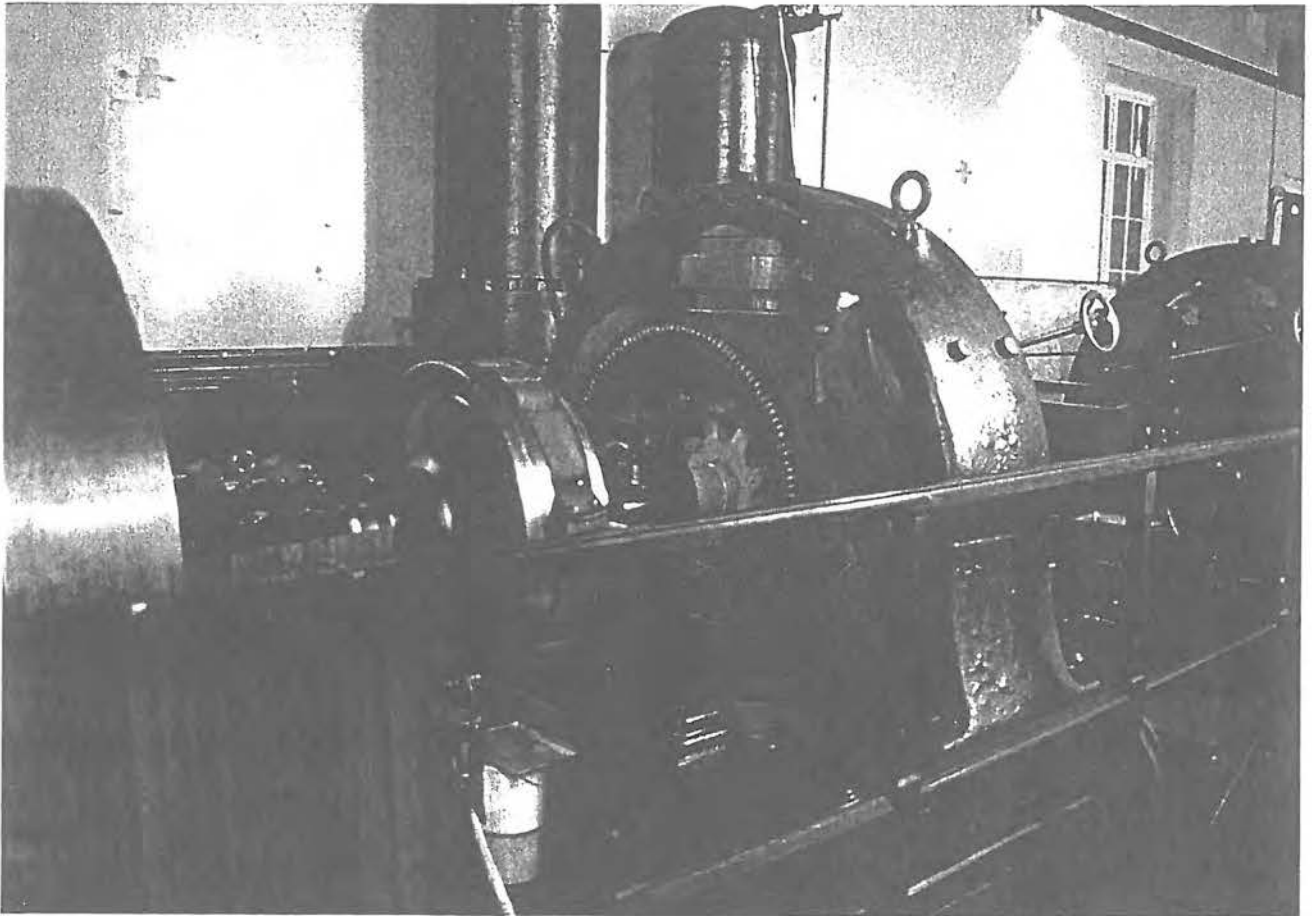
Another method of hauling rock to a higher level was the powered incline. This example at Aberllefenni used the weight of a rail-mounted water-tank to draw the loads upwards on a parallel track.



At the incline summit the rope was passed either round a drum on a horizontal axis, or, as here at Hafodlas quarry, Betws y Coed, a sheave.



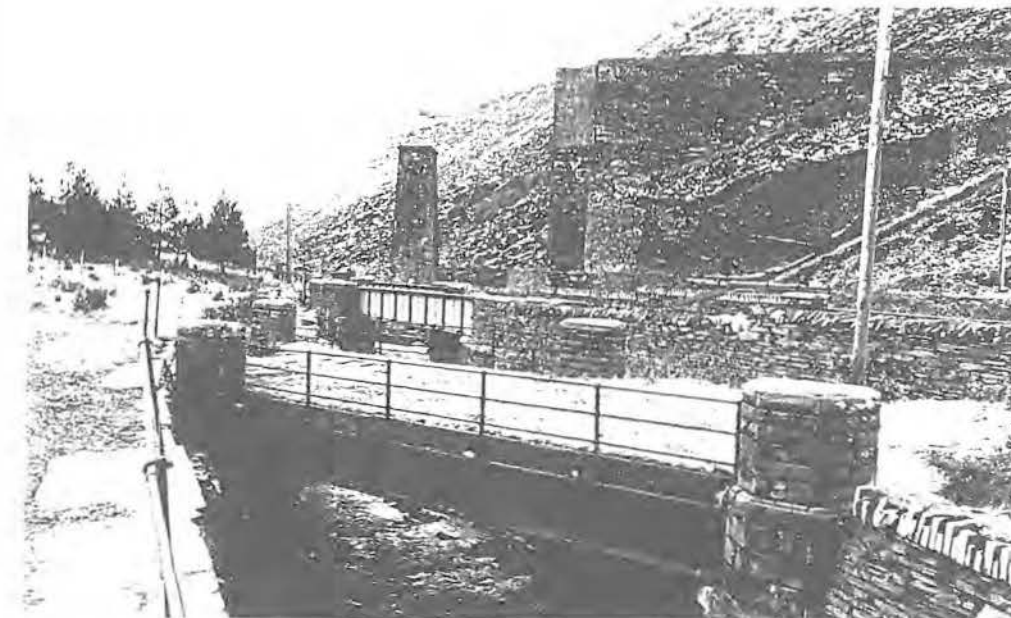
The slate quarries were pioneers in the early use of hydro-generated power. This d.c. station of 1904 remains in use at Llechwedd quarry, complete with its original machinery.



A view inside the Llechwedd power house, where Gilbert Gilkes peltons operate
Johnson and Phillips 175 kw d.c. generators.



The Llechwedd power house is visible in the bottom right of this photograph, which shows the remains of the Welsh Slate Company's viaduct. This gave access to a tip and a mill area on the far side, which were removed for hardcore in the 1970s. Underneath it ran the Festiniog Railway, joined from 1879 by the LNWR's Blaenau branch, still operational.



Very few quarries had direct access of their own to a standard-gauge railway as Llechwedd did. This view shows the LNWR's sidings to the Llechwedd transshipment wharf.



Some quarries built their own transport links to the sea. This shows the route of the 3' gauge Gorseddau railway to Portmadoc, running alongside the quarry's distinctive retaining wall.



The remoteness of many of the sites obliged managers to build accommodation for their men. This building, the quarrymen's barracks at Glanrafon quarry near Rhyd Ddu, is the only known Gwynedd example of a dual row, a building constructed against a hillside in which entrance to the ground floor was at one side and to the first floor at the other.

