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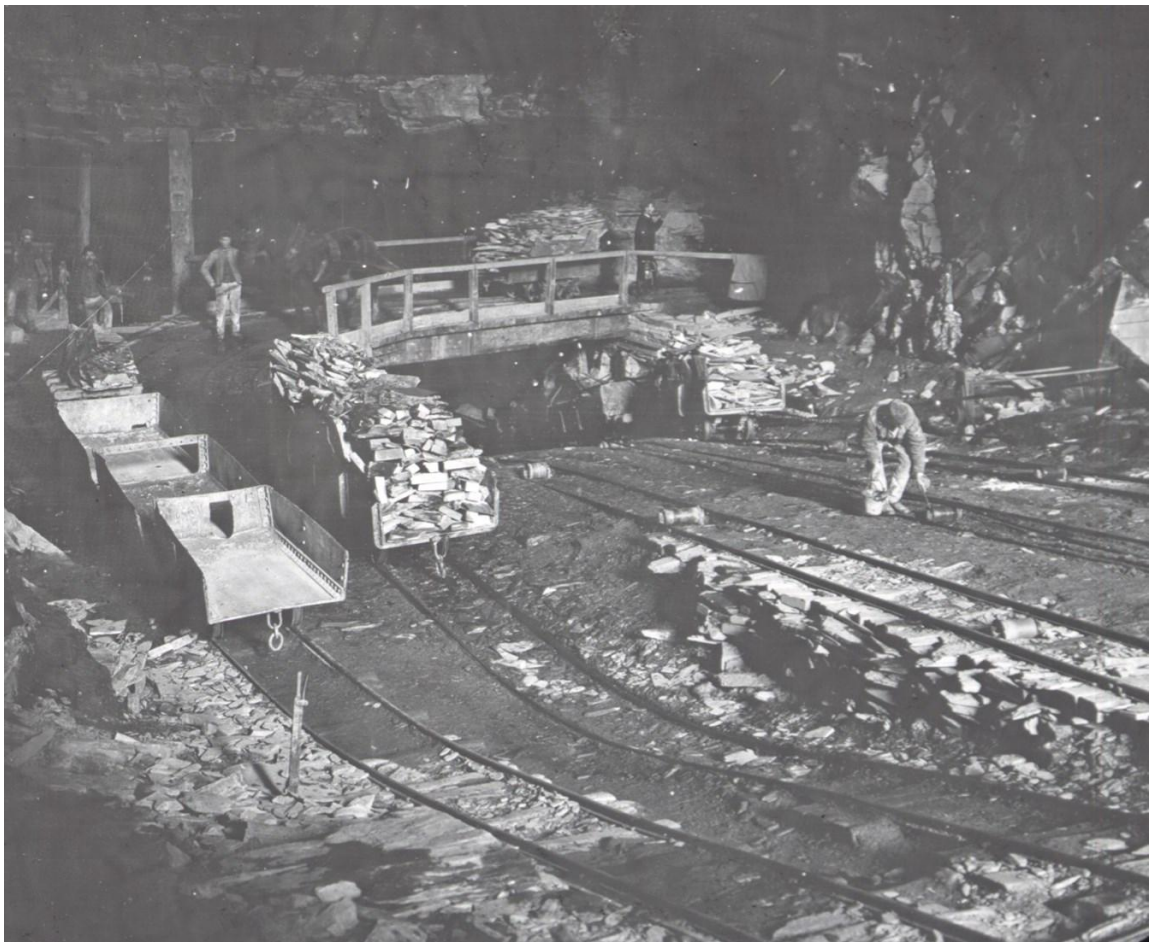


SLATE INDUSTRY OF NORTH WALES

ARCHAEOLOGICAL ASSESSMENT OF UNDERGROUND FEATURES THEIR CONDITION AND PROTECTION

By David Gwyn and Jon Knowles for

Gwynedd Council

August 2017
Govannon Report GC405

SLATE INDUSTRY OF NORTH WALES

ARCHAEOLOGICAL ASSESSMENT OF UNDERGROUND FEATURES, THEIR CONDITION AND PROTECTION

EXECUTIVE SUMMARY

Gwynedd Council is currently (2017) promoting a bid to inscribe a number of significant areas within the slate industry of the area as a World Heritage site (Slate Industry of North Wales). As part of the process of preparing a bid, the Council has commissioned Govannon Consultancy to provide technical advice, including an archaeological assessment of the underground areas of working, transport and drainage associated with sites proposed for inclusion in the bid. The present document fulfils that part of the brief. 110 sites within 7 different quarries were identified, if which 17 were assigned to category U (Site requiring further investigation), 93 to category AA (Internationally Important).

ABBREVIATIONS

The following abbreviations are used:

DCMS: Department of Culture, Media and Sport
GAT: Gwynedd Archaeological Trust
GC: Gwynedd Council
HER: Historic Environment Record
NAMHO: National Association of Mining History Organisations
NMR: National Monuments Record
OUV: Outstanding Universal Value
RCAHMW: Royal Commission on the Ancient and Historical Monuments of Wales
SNP: Snowdonia National Park
UNESCO: United Nations Scientific and Cultural Organisation
WH: World Heritage

TERMINOLOGY

The following terminology has been adopted.

Bastard: un-remunerative slate rock, not worth quarrying for commercial purposes
Chamber: an underground area of worked slate
Floor: a working area on a single horizon in an underground quarry, comprising the *chambers*, the *level* and any other features in it
Level: the underground passage which gives access to *chambers* and any other features on a particular *floor*
Pillar: the area of worked slate between *chambers*
Sinc: an area that is 'sunk', an open pit, sometimes created by de-roofing *chambers* and removing the *pillars*
SRT: single rope technique

DEFINITION

The following definitions of accessibility have been adopted:

Accessible by the public - access is open to the general public as part of a visitor-attraction operated by the site-owner

Accessible by non-specialist - access is possible by individuals with a reasonable level of agility and fitness, if equipped with helmet and lamp

Accessible by specialist – access is possible by competent individuals experienced in SRT

1 INTRODUCTION

1.1 Context

Gwynedd Council is currently (2017) promoting a bid to inscribe a number of significant areas within the slate industry of the area as a World Heritage site (Slate Industry of North Wales).

Hitherto, surface features of the industry have been assessed for their archaeological significance but no assessment has been carried out of underground locations where slate was worked, where output was moved to surface and where water was drained.

Govannon consultancy has been commissioned by Gwynedd Council to carry out an assessment (the present document) of underground locations within sites provisionally identified for inclusion in the bid. It was confirmed that Govannon would present a written report for the client, setting out management recommendations, ensuring that the client and partners (Cadw, RCAHMW) have a consistent knowledge-base of the site-type and understanding of its high-value attributes carrying OUV for inclusion in the gazetteer and nomination document, that the format will be suitable for Nomination Document sections 2.a and 4.a/b and 5, and that the HER and NMR records can be appropriately enhanced.

1.2 Personnel

This assessment has been carried out by Dr David Gwyn of Govannon consultancy and by Jon Knowles.

Dr David Gwyn is a consultant archaeologist of many years' standing and is author of the RCAHMW study *Welsh Slate: History and Archaeology of an Industry* (2015).

Jon Knowles BEng is currently Engineering Consultant to JW Greaves & Llechwedd Slate Mine, having previously worked for Sulzer Pumps, NEI-Allen Ltd and Belliss & Morcom; he is a mine explorer and industrial archaeologist with over 30 years' experience, as well as an underground photographer specialising in Welsh slate mines. He is writing a definitive history of Aberllefenni Slate Quarry.

2 COMPLEMENTARY STUDIES AND PUBLICATIONS

This project complements both former projects and a series of current initiatives which together help identify the attributes which define the OUV of the industry and the management of those attributes.

A number of reports have been produced in preparation for the World Heritage bid. These include:

- Gwyn, D., 2012 *Baseline study and technical evaluation: the slate industry of North Wales tentative World Heritage Site* (Govannon Report 295)
- Davidson, A., and Gwyn, D., 2014 *Gwynedd Slate Industry Transport Routes* (GAT Report 1207)
- Gwyn, D., 2015a *DCMS Review of Slate Industry World Heritage Bid: Considerations* (Govannon Report GC 335)
- Gwyn, D., 2015b *Stone Quarries as World Heritage Sites* (Govannon Report GC 335)
- Gwyn, D., 2015c *International Slate Quarrying Landscapes* (Govannon Report GC 335)
- Gwyn, D., 2015d *Criteria for scheduling slate quarry tips as ancient monuments*
- Hopewell, D., 2016 *Slate Industry of North Wales: Scheduling Recommendations A Pilot Study* (GAT Report 1295)

Relevant detailed reports have been carried out by the SNP-sponsored 'Practical Industrial Archaeology' courses on Penrhyn, Pen yr Orsedd, Pen y Bryn, Tal y Sarn, Llechwedd, Maenofferen, Bryneglwys and Aberllefenni quarries. These are kept at the National Park Study Centre, Plas Tan y Bwlch. These have been carried out on a site-by-site basis, and whilst they contain much valuable information, they do not in themselves constitute an overall and comprehensive record of the resource.

Also relevant are Graham Isherwood's published survey of Cwmorthin quarry (Isherwood 1995), Alan Holmes' survey of Bryneglwys (Holmes 2013), David Gwyn's 'Power Systems in Four Gwynedd Slate Quarries', *Industrial Archaeology Review* 22 2 (Gwyn 1999), and the same author's publication on the history and archaeology of the Welsh slate industry - *Welsh Slate: Archaeology and History of an Industry* (Gwyn 2015e).

3 METHODOLOGY

3.1 Rationale

Previous archaeological assessment of potential assets demonstrating OUV have been limited to surface features, yet it was clear that underground workings at Ffestiniog, Bryneglwys and Aberllefenni, and drainage systems at Penrhyn, Pen yr Orsedd, Tal y Sarn and Pen y Bryn (Nantlle), where they were accessible or were evident as surface features (for instance as ventilation shafts), needed also to be assessed to see which ones demonstrate OUV. We note here that there is now an expectation on the part of UNESCO that World Heritage mineral sites will include underground features.

3.2 Approaches to assessment of underground mineral-extraction sites

Hitherto (2017) few underground mineral-extraction site types have been consistently assessed as an archaeological resource. Challenges to doing so reflect the difficulties of access, of preparing accurate maps, and the amorphous nature of features that chase geological strata or mineral deposits. Prehistoric mines such as those on the Great Orme 'are even suggestive of natural cave passages' (Lewis 1990) and do not lend themselves to a detailed mapped record. Craddock 1994 sets out ways in which a drawn record can be prepared.

3.3 Terminology

Assessment is not made easier by the absence of any definitive thesaurus of mining features. NAMHO 2002 notes:

> Mining terminology is riddled with regional and period specific terms which can lead to confusion. These local terms are an important aspect of mining history and their use should not be discouraged, however where possible terms should be qualified with widely used generic mining terms. It is important to remember that there is also a great difference between terms used for features in different branches of the mining industry, particularly in the cases of coal and metal mining.

These problems are compounded by Welsh and English terms being used side by side or adapted from one language to the other. The Thesaurus of Monument Types for Wales identifies SLATE MINE ('an excavation made in the earth for the purpose of digging out slate. Usually used for underground working'), and terms related to MINE, namely ADIT, DRAINAGE LEVEL and MINE BUILDING. ADIT is

defined as 'Horizontal tunnel opening from the surface used for haulage or access to a mine. In Wales it is a term usually applied to a drainage level.'

The approach followed in the present document has, by agreement with the HER and RCAHMW, been developed with a view to being used in a wider variety of such underground mineral-extraction sites than purely slate mines, by creating a hierarchy of inter-related sites, capable of inclusion in a relational online database at three levels, namely:

Parent record (Level 1)

The parent record refers to, and includes a summary description of, the entirety of underground workings on a particular site as a SLATE MINE, if extraction took place, or to DRAINAGE LEVEL and/or HAULAGE TUNNEL, depending on function, to rank equally with the record which describes its corresponding surface features.

Parent records are indicated in the report with a 3-line border around the relevant entry.

Child records (Levels 2 and 3)

The child record is a summary description of each significant sub-division of each discrete underground site (the Level 1 record), or of important elements within it. For the purposes of the present document, this was generally considered to be each FLOOR of the workings, including the LEVEL (the transport tunnel which carries material out of the mine and enables pedestrian access) and any CHAMBERS worked off it, as well as particularly significant features which run from one floor to another, such as STAIRWAYS and INCLINED PLANES.

Child records (Level 2) are indicated in the report with a double-line border around the relevant entry.

In some cases the child record can be further subdivided into important elements (Level 3). For instance, an INCLINED PLANE as described at Level 2 might typically have two features at Level 3, namely the WINDING GEAR/ HAULAGE EQUIPMENT and the FORMATION of the incline itself. The term WINDING HOUSE for the head of the inclined planes has been used where a built structure dominates or where little or no machinery survives, WINDING GEAR where significant amounts of machinery predominates.

Other features which might merit an entry at Level 3 could be a chamber or level which contains a CABAN ('a structure ... where quarrymen gathered for their lunch break.... Often a place where political discussions were held, as well as other cultural activities such as poetry readings and musical performances') or a RAILWAY (a well-preserved section of track), a CRANE or a COMPRESSOR. Features within this category are indicated in the report by a single line border. Note that the particular CHAMBER or the LEVEL is still taken as the monument at this level.

3.4 Scope

Given that the existing level of knowledge of the archaeology of underground features of Gwynedd slate mines is patchy and inconsistent, the main scope of the assessment has involved systematising existing information by:

- Identifying the locations of significant features and artefacts
- Identifying attributes/high end carriers of OUV

- Preparation of map coverage to inform future management, given GC's evolving understanding of the requirements of the WH bid
- HER and NMR enhancement

It was agreed with the client that the assessment should encompass the sites provisionally identified for inclusion in the World Heritage bid where there were known to be underground features, namely Cwmorthin, Llechwedd and Maenofferen (Ffestiniog area), Bryneglwys and Aberllefenni, or drainage systems, namely Penrhyn (Ogwen valley), Pen yr Orsedd and Tal y Sarn (Nantlle) and Oakeley (Ffestiniog), and that it would not consider areas not proposed for inclusion.

In the case of Aberllefenni, given changes in ownership, visits were not undertaken, and the exercise conducted purely as a desk-top study, drawing on Jon Knowles' detailed recent exploration of the site when under the ownership of Wincilate.

It was not proposed to assess the underground workings of two quarry sites which are likely to be included within the bid, namely Wrysgan, on safety grounds, and Diffwys Casson, in that underground workings are small and unrepresentative. It is noted that there are also significant underground workings in slate quarries within Gwynedd in the Croesor area, as well as in other counties such as Nantconwy and Denbighshire.

In the event, two sites proved to have become inaccessible, namely the drainage levels at Pen yr Orsedd quarry in Nantlle and the *Lefel Galed* at Oakeley, which is understood to have suffered a recent collapse. The assessment therefore excludes these sites.

3.5 Documentation

Archive underground plans were identified for Llechwedd, Maenofferen, Bryneglwys and Aberllefenni. Published studies by Isherwood 1995 and Holmes 2013 of Cwmorthin and Bryneglwys respectively were consulted, together with the existing detailed archaeological archive at Plas Tan y Bwlch/Snowdonia National Park Study Centre.

3.6 Health and safety

A Health and Safety assessment was drawn up as part of the report and agreed with the client. This is reproduced as Appendix 2.

3.7 Site exploration

It is clear that knowledge of the archaeological resource continues to expand, as exploration continues, and as enthusiast groups gain access to blocked levels, or as parts of mines can be de-watered. By the same token, the threat of flooding, or of instability arising from surface blasting or other causes, conversely makes it possible that some areas will become inaccessible in the future.

On the basis of the contractors' knowledge of the sites, it was concluded at the outset of the project that much of the 150km (approx.) of underground workings in the slate industry of Ffestiniog is now inaccessible and in many cases flooded, but that good examples of the various distinctive forms of mining for slate do survive, that they could be reached and assessed, and are likely to include essential attributes of the bid.

Site-visits were undertaken from September 2016 to June 2017 with the owners' permission. Significant features were noted on plans, and recorded photographically using a Canon EOS1 DS

Mark III. Important geological features which influenced methods of working, together with details of surviving machinery, structures, incline planes *etc* which are considered to be a potential attribute of OUV were noted.

3.8 Preparation of archaeological records

As far as possible, the floor (the tunnel and any chambers worked off it) was taken as the basic Level 2 unit of record in each case. Each floor was identified by its approximate height AOD in metres (with the reservation that these are a best guess, and that floors are rarely entirely level) and as far as possible, key locations identifying where the floor either emerges to daylight or connects to an inclined plane, as well as the most distant point of working, or of accessibility, were identified by surface grid reference. In the case of Aberllefenni, a different approach was followed, in that chambers run from floor to floor in a near-vertical alignment; this is discussed in more detail in *4.2.2*. For this reason, both floors and chambers were taken as the basic Level 2 units of record.

It was agreed that details would be passed on to HER/NMR as well as to the clients.

3.9 Preparation of maps

In the case of Cwmorthin and Bryneglwys, existing published maps (Isherwood 1995 and Holmes 2013) were considered sufficiently accurate to be used for exploration and to form the basis of maps used in this report. No such maps were available for Llechwedd and Maenofferen, and archive maps were consulted instead; these were kindly made available by J.W. Greaves Welsh Slate. These maps offer the challenge that separate surveys were carried out for different veins, and therefore it was necessary to amalgamate information from several different documents. For Penrhyn quarry, archive maps in the authors' possession and Plas Tan y Bwlch surveys were used. For Tal y Sarn quarry, Plas Tan y Bwlch surveys were used as no other documentation was available. Published, archaeological and archive maps were read into a GIS system and digital maps prepared by RCAHMW for inclusion in the final report. These maps show the scale of each site and identify which parts are accessible. The maps follow a convention whereby each floor is colour-coded separately. Features that pass from one level to another, or which emerge to daylight, are shown in black.

For linear features such as floors, inclined planes and stairways a central grid reference is given but the maximum extent (or known extent) of each feature is identified by two terminal grid references in the text, generally the furthest point from the surface that is currently accessible (which need not be the furthest point of the level itself), and the point at which it reaches daylight, or joins on to a transport system such as an incline or a shaft which takes it to surface.

Similarly with inclined planes; the first grid reference is generally the lowest currently accessible, though many underground inclined planes are flooded on their lower level. The second is the location of the incline head/winding mechanism.

Levels, chambers and other features have been identified by the names by which they were known at the time of working, as most of the published historical and archaeological studies use these also. Whereas open levels and other features in surface slate quarries in Wales were often given fanciful names, underground features tended to be referred to in more prosaic ways. There is still potential for confusion here, as sometimes floors were numbered, and sometimes lettered, some maps number the chambers and some the pillars between them. Some quarries numbered chambers in a simple numerical sequence, some distinguished between those to one side or the other of the incline which served them. In the present document, each floor is identified by the number or letter it had when the quarry was active, and each chamber is identified first by its floor, then by its unique

identifier within the floor, generally a number but sometimes followed by an (East) or (West), followed by the vein it worked if the mine worked more than one vein.

For instance, the chamber with probably the greatest artefactual survival in the industry, at Cwmorthin slate mine is identified as E/1(W) (BV), in that it is located on floor E, it is the first chamber to the west of the up-haulage incline to surface, and it worked the Back Vein.

Features that are common to more than one level such as stairways and inclines are identified in the report either by the name by which they are best known (*eg* the Back Vein incline at Maenofferen slate mine, or by the levels at top and bottom; in either case, the free text indicates not only the top and bottom levels of the feature but also an intermediate levels it served.

3.10 Photographic record

A representative selection of photographs of the most significant features has been included in this report.

3.11 Copyright

As noted, photographs of significant underground features have been included in the documentation. However, by arrangement with the client, Govannon reserved the right to use existing photographs in our possession to support the bid whilst retaining copyright. Where photographs have been taken as part of this commission, the copyright passes to the client.

3.12 Categories of significance

On the basis of professional judgement, slate mine sites and individual components within them were assigned to one of other of the following categories of significance.

(code)	(term)
AA	International Importance
A	National Importance
B	Regional Importance
C	Local Importance
D	Minor site
U	Site requiring further investigation
NR	Not Recorded

4 HISTORICAL CONTEXT

4.1 Mining in a world-wide context

4.1.1 Key features

The extraction of stones and minerals from a sub-surface context is attested from Prehistory, and its archaeology has been extensively studied. Key features are:

- The areas where extraction takes place
- The subterranean passages through which whatever mineral extracted is transported to surface
- Drainage – the means by which the workings are kept clear of water

It is no part of the present document to outline the history and development of these features in a global context, but a brief summary is provided to contextualise the archaeology of slate mining in Gwynedd.

4.1.2 Extraction areas in world mining

The shape and form of extraction areas in any mine vary considerably according to the mineral extracted and its geological context. A narrow, near-horizontal seam of coal will require a very different approach to a near-vertical copper lode. The extraction of slate blocks from an inclined bed or 'vein' required the opening of large, regularly-ordered chambers. The use of explosives to detach useful minerals becomes commonplace from the 17th century to the 19th. Powered drilling superseded hand-drilling throughout the developed world in the late 19th century.

4.1.3 Passages in world mining

The subterranean passages along which minerals are taken to surface also vary considerably. Some mines could make use of near-horizontal levels, commonly referred to as 'adits', connecting the extraction areas with daylight. Minerals might be carried on miners' backs, or on sledges, on railways (attested from the Roman period) or in wheelbarrows (from Medieval times). Such levels often required supports, whether timber, masonry or iron/steel.

Vertical mine-shafts are of ancient origin. These might be wound by a human operating a windlass, a horse operating a gin, or by a mechanical device such as a water-wheel, a steam engine or other prime-mover activating a haulage drum or a sheave wheel. Where the bottom of the shaft lay above the mine's drainage level, a water-balance system might be used.

4.1.4 Drainage in world mining

A mine where any water collected could be made to flow out to surface is referred to as 'self-draining'. More often, some mechanical intervention is required to keep workings free of water. Machines activated by water which lift water into an aqueduct and the force pump are known from Roman mining contexts. Rod-engines which transfer power from a surface prime-mover to a distant underground pump were devised in the late 15th century, and the harnessing of high-pressure steam and of high-pressure water to mine-pumping in the 18th century was an important contributory factor to industrial 'take-off'.

4.2 Mining in the context of the Welsh slate industry

4.2.1 Context

Slate is often described as being found in a 'vein', a horizon of rock of suitable quality. Welsh slate is derived from sediments deposited in three main periods of geological history, Cambrian, Ordovician and Silurian. In north-west Wales, only Ordovician rock has been extracted by mining. The orientation of the vein determines the method by which the slate can be extracted – where it dips steeply this can be by open quarrying, but where it dips at a lower angle (such as at Ffestiniog, where it is oriented at around 30°), slate has to be won underground once workings develop.

Though the slate industry of North Wales has its origins in the Roman period and experienced a period of slow growth in Medieval and Early Modern times, it is only in the period of major capitalisation in the 19th century that underground extraction took place on any significant scale, and that subterranean passages and also pumping systems became necessary. Underground features

include the ‘chambers’, the extraction areas where raw slate blocks and unworkable rubble were removed from the parent rock, the ‘levels’ (tunnels) and inclines by which they were transported to the surface, and the means of drainage. Drainage features are not only associated with slate mines but also deep surface pits such as Penrhyn quarry. The technology of these features reflect the developments of the 19th and 20th centuries – 0.6 m gauge railways, inclined planes, and the use of balance engines, steam, electricity and compressed air.

Since the near-terminal contraction of the industry in the 1960s, some underground sites have become tourist attractions. Llechwedd quarry developed historical tours in its underground workings, one of which has now been re-imagined as ‘Bounce Below’, a cavern trampoline. Commercial, managed underground exploration takes place at Cwmorthin quarry, and negotiated access is also possible at Bryneglwys, through Cave Access Ltd. a company created to manage recreational access to various mines and caverns. Unauthorised access takes place at Maenofferen. Social media websites provide information for would-be explorers and for trespassers.

4.2.2 Extraction areas

The form of underground extraction is dictated by the geology of the rock in which levels and chambers were cut.

Slate is a metamorphic rock, changed from its original form and composition by heat and pressure, and is often described as being found in a ‘vein’, a horizon of rock of suitable quality. Welsh slate is derived from sediments deposited in three main periods of geological history. The predominantly dark grey slates of the three areas with underground working identified for inclusion in the Slate Industry of North Wales World Heritage bid, namely Ffestiniog, Bryneglwys quarry and Aberllefenni quarry, however, are all of the Ordovician period. The orientation of the vein determines the method by which the slate can be extracted – where it dips at a low angle at Ffestiniog, where it is oriented at around 30°, slate has to be won underground once workings develop. Bryneglwys quarry, where it dips steeply, was initially worked by open quarry pits, but went over to underground extraction; similarly Aberllefenni, where topography made it easier to approach the vein by means of level tunnels and to work the rock in tall chambers.

Slate ideally has three planes of fracture, which enable the rock to be extracted as manageable blocks. Slaty cleavage is the most important of these, as it enables the rock to be split into thin laminae, and hence confers on it an economic value.

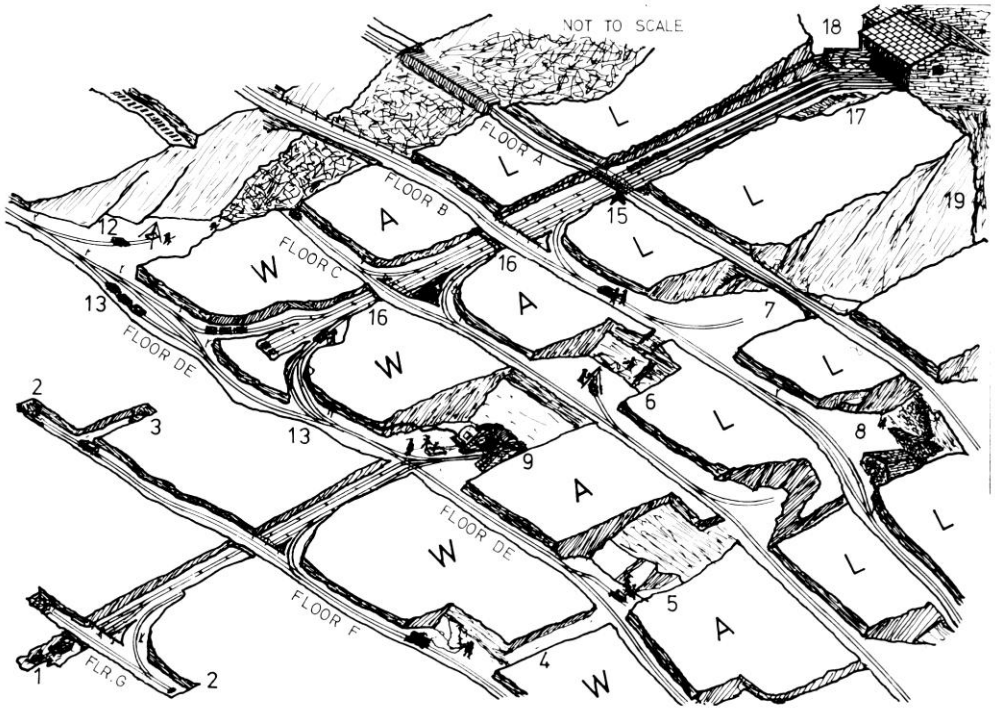
The other natural joints formed by geological processes also play an important role in slate working. Where they are suitably oriented, they can be used to extract the rock. One is the ‘grain’ or pillaring line, a near-vertical plane. Another is the ‘foot-joint’, across the plane of cleavage. Where this does not exist or is insufficiently developed, ‘channelling’ (drilling a set of holes) causes the rock to snap at this point when it is blasted along the pillaring line. Others, such as ‘bevels’, are faults running diagonally across the cleavage, which detract from the rock’s value.

The underground workings at Ffestiniog, Bryneglwys quarry and Aberllefenni quarry are still called *chwareli* (‘quarries’) or archaically *cloddfeydd* (‘diggings’) in Welsh, though sometimes in English they might be referred to as ‘mines’. For the purposes of the present document, the site-type *slate mine* is to be understood as a sub-set of *slate quarry*, and to include all identified underground features.

The earliest underground workings within areas proposed for inclusion in the WH bid are located in Ffestiniog, and date from the early or mid-19th century. The five veins in this area (the North, the Back, the Narrow, the Main or Old and the South or New) dip from south to north at an angle

normally of between 20º and 35º (the dip of the plane of cleavage is about 45º), with the result that anything more than minimal extraction requires the removal of the intervening 'hards' (cherts), and of overburden on a significant scale. In the earliest mines in Ffestiniog, the roof was supported on pillars of slate that are left un-quarried as free-standing columns; some examples have been identified at Maenofferen quarry. This method was abandoned in favour of separate chambers, which was safer but made less use of the rock. The word 'pillar' survives to mean the wall of slate between each chamber. Samuel Holland stated that he had initiated the change at Ffestiniog following a visit to Lord Dudley's limestone quarries in the English West Midlands in 1838.

Typically, a Ffestiniog slate mine will have evolved around an inclined plane dropping from a processing and tipping level into an open *sinc*, then disappearing from sight through a cavernous opening in the rock face immediately under the hard, following the dip. Once the miners had driven the shaft for the incline, they drove lateral tunnels known as 'levels' along the strike at vertical intervals of about 12 metres (40 feet) to give access to workable rock; further inclines underground as necessary gave access to deeper levels still (see diagram **1** below). There were variations; some of these underground workings were accessed by a level from the open, of which examples are evident at Cwmorthin, Llechwedd and Maenofferen, and at Oakeley some were reached by a vertical shaft.



1. Isometric view of a typical Ffestiniog slate mine, showing incline, pillars (walls) and chambers. © Graham Isherwood.

The levels themselves are often, but by no means always, near-triangular in section, reflecting the slant of the hard. They are mostly driven through solid rock, but shoring, where required, was built up out of slate rubble or out of timber. Very occasionally, such as at one location in Oakeley, it is known from historical sources that masonry work was used. Tunnels had to accommodate not only a railway but also often compressed air piping, and they also carried away water.

The preparatory work on a chamber involved driving an inclined shaft (*rŵff* or 'roof') upwards from the level under the hard, which provided a starting point for opening out a chamber. The roof was then successively opened out sideways, and a trench cut at one end to provide a free side along the pillaring line. From these, the rockmen could quarry the slate, creating a wedge-shaped opening which grew progressively larger as the forebreast (the working face) was advanced away from the level. Each chamber is worked upwards; often the inclined shaft was cut into the floor above to provide ventilation, and frequently the whole chamber would join the corresponding chamber on the floor above, creating long sloping caverns, or would break through to the original open quarry or *sinc*.

Chambers might be about 15 metres wide and pillars about 9 metres wide, though at Wrysgan (not surveyed) some chambers were 40 metres wide with pillars of only 15 metres. Yielding to the temptation to 'shave' pillars for good slate could and did have disastrous results, as a collapse could very easily take with it a whole series of chambers on higher levels. Quarry leases in Ffestiniog were complicated affairs in which different companies were allotted not only specific surface plans but also different underground levels, one on top of another; an accident would keep lawyers, if no one else, rich for years to come. A series of falls at the Lower (Welsh Slate) Quarry (now part of the Oakeley site) in 1882–83 threatened to destabilise Holland's and Matthews' quarries in the upper part of the site.

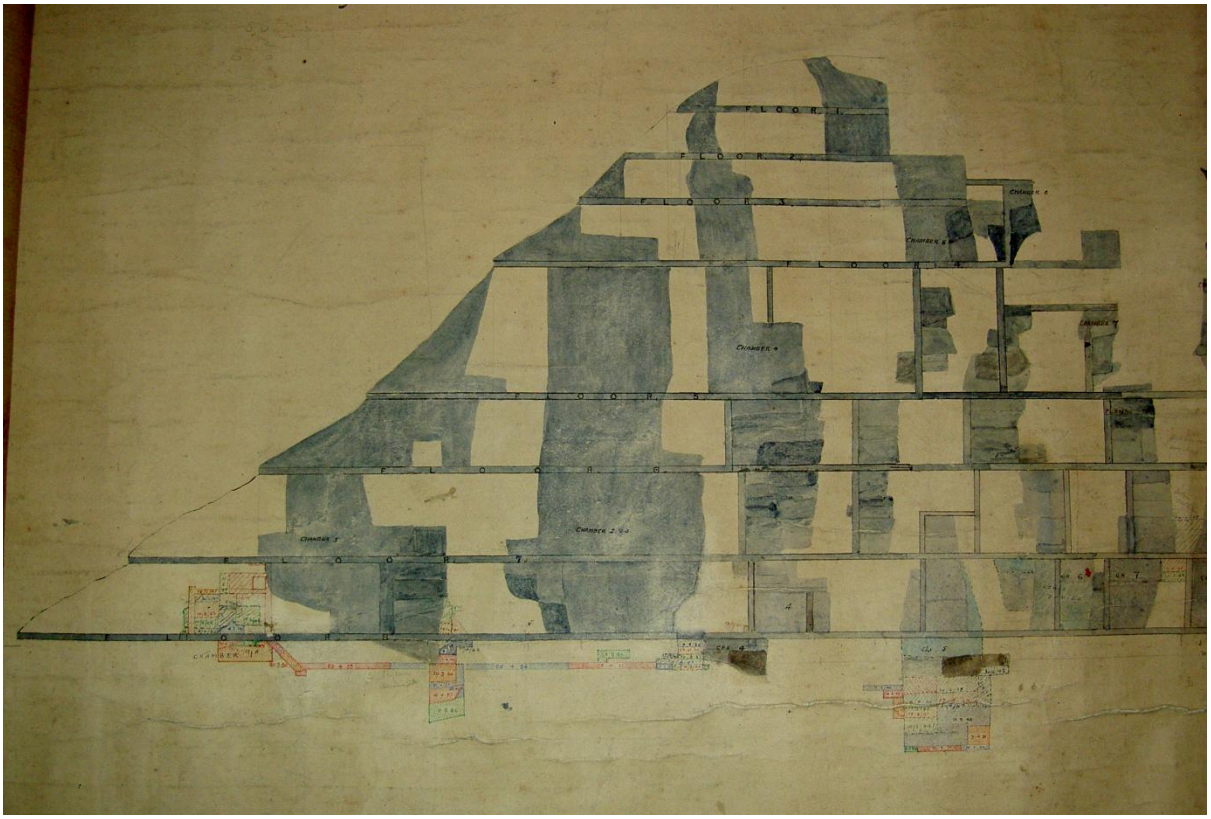
Underground quarries preserve many examples of roofing shafts that were never developed into chambers, and of chambers that were never fully exploited, either because the company folded or the results proved disappointing and the rockmen moved on. A successful chamber might be worked for a generation and then abandoned, or used to house compressors or pumps, or as a *caban*.

This form of underground quarrying proved an effective way of extracting slate until the arrival of large earth-moving machinery in the mid-twentieth century, when overburden removal became easier.

At Bryneglwys, two veins were worked, the Broad Vein, in which the underground workings are now inaccessible, and the Narrow Vein, much of which can be reached. This dips at between 50^{o} and 60^{o}, with near-vertical cleavage, and was worked on seven floors, numbered, in descending order, 5, 10, 15, 20, 25, 50 and 75, as well as from an open pit from which a chain incline system raised blocks and slate rubble.

At Aberllefenni in the Dulas valley, from the early nineteenth century, a bed 20 metres thick dipping at an angle of 70^{o} to the south-east was accessed by levels from the early 19th century from the open along the strike of the vein. Here, chambers were created by cutting a shaft from a horizontal opening across the top of the vein; this would be opened out laterally to the width of the slate bed by cutting away horizontal slices from the chamber floor. The result was that many chambers, though by no means all, thereby became united with chambers on higher and lower floors to produce openings which may be as much as 57 metres along the strike and which in some cases open out onto the hillside 170 metres above.

These can best be visualised by examining the cross-sections of the Foel Grochan workings below (**2** and **3**) in the light of the information in **Appendix 2**.



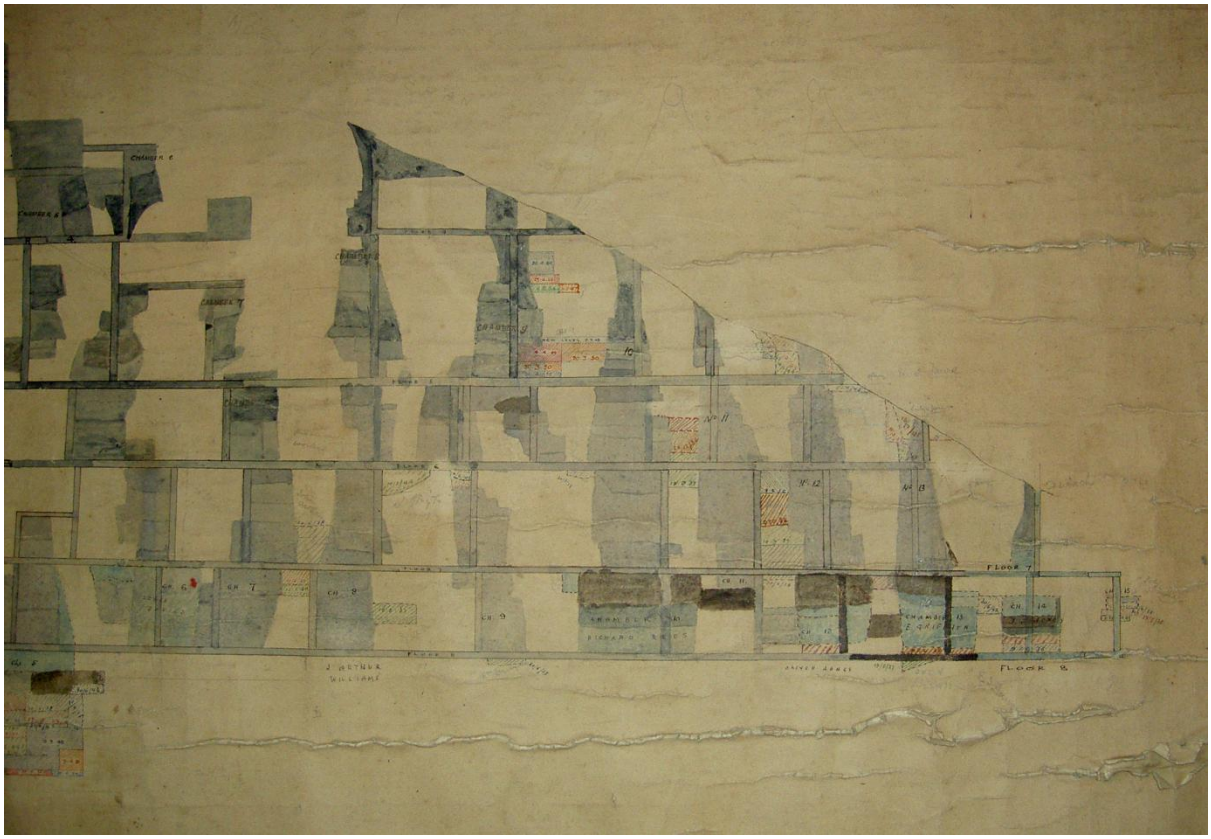
2. Cross-section from south-west (left) to north-east (right) of the Foel Grochan workings at Aberllefenni Slate Quarry, showing how the tunnels on the different floors follow the vein and cut through the mountain ridge to serve chambers which in some cases extend to the surface. Floor 8 is the lowest of the floors to reach daylight on the left of the diagram; Floor 9, now flooded, was formerly accessed by an incline from Floor 8, and is shown here in red. Floors 1 to 6 are evident on the upper slopes of the ridge.

Pillars at Aberllefenni are about 7-9 metres thick. Blocks would be lowered from the chamber walls to the next level down by hand cranes, then loaded on flat wagons which would then be pushed to the opening of the level and so to the mill, except for the lowest levels, where blocks had to be raised. At a couple of points in more recent times, mechanical cranes were installed near the open tops of the chambers and blocks lifted out to where they could be loaded on to road vehicles. The lowest level came to be reached by an underground incline from the valley floor level, and the last chamber to be worked before extraction ceased in 2003 made use of an aerial cableway raising the blocks on a hoist. Chambers on the same principle were to be found at other quarries nearby, such as Cymerau and Ratgoed.

4.2.3 Passages

Transport-needs in a slate mine involve the movement of raw blocks of slate for processing on the surface, slate rubble for tipping on the surface or in a worked-out chamber and the movement of machinery and fuel underground. This was nearly always carried out by 0.6 metre gauge railway. Quarrymen would generally walk along the levels to and from work, though special vehicles were sometimes provided for them on inclined planes. In addition, separate walkways and stairways were occasionally provided to prevent men having to negotiate constricted spaces on an inclined plane where a runaway wagon might kill or maim them.

Surviving rails, point-work and wagons are frequently encountered in the context of a slate mine.



3. A continuation of 1., showing the floors on the north-eastern side of the ridge. Some of these reach daylight.

Inclined planes were the most common means of overcoming differences in height between floors. These typically had to haul against the load, and therefore required a prime-mover at the summit. Inclined planes might be constructed through abandoned chambers or run through dedicated underground passages. Some emerge to daylight, such as the Back Vein incline at Maenofferen, others are completely underground. In many cases the rails and the haulage machinery survive, though high prices offered for copper have meant that in many cases components have been damaged by thieves.

A variant on this system is an inclined plane at Bryneglwys slate mine, where the water-wheels which drove the chain incline system in the open workings introduced by Nantlle quarrymen in the 1860s also hauled wagons up a railed underground incline from the lowest part of the mine. It is currently inaccessible by non-specialists, but the tunnel mouth is evident.

Other transport systems in slate mines include cranes, ranging from small wooden hand-winches to steel derrick structures, of which the largest are in Aberllefenni slate mine. Vertical shafts for railed cages were widely used at Penrhyn quarry, where two survive with their machinery. These were associated with open working rather than with mining, but they made good use of the un-remunerative 'bastard' rock on the north side of the quarry pit to provide an effective means of up-haulage to the main processing area.

The levels themselves are often, but by no means always, near-triangular in section, reflecting the slant of the hard. They are mostly driven through solid rock, but shoring, where required, was built up out of slate rubble or out of timber. Very occasionally, masonry work was used. Levels had to accommodate not only a railway but also often compressed air piping, and they also carried away water.

4.2.4 Drainage

Penrhyn quarry from 1849 made use of the longest single drainage tunnel in the slate industry, running for approximately 2 kilometres from the pit to the Ogwen river. Here, the area of the excavation covered 52.6 hectares (130 acres) by the early years of the twentieth century and a night of rain meant that nearly 3,000,000 gallons would fall on it.

Pen yr Orsedd quarry in Nantlle installed an ambitious deep drainage system in the 1860s and 1870s, which ensured its survival as a working quarry for over a hundred years. Tal y Sarn quarry has a shallow underground drainage system.

Sometimes levels also removed water, with a slab-lined water channel running between the rail tracks, but more often a channel or simply a depression to one side of the level.

Pumping machinery is sometimes associated with underground features, either in the form of a totally underground system or as a surface prime-mover connected to a pump below ground.

5 FINDINGS OF THE ASSESSMENT

The project has established that seven sites proposed for inclusion in the World Heritage bid and which are known to have had underground workings and/or drainage levels were accessible in part, namely Penrhyn, Tal y Sarn, Cwmorthin, Llechwedd, Maenofferen, Bryneglwys and Aberllefenni slate quarries. This section summarises the detailed record of these sites which constitute Appendix 1.

5.1 Penrhyn Slate Quarry underground workings PRN: 67518 NPRN: 546400

5.1.1 Location

Penrhyn Slate Quarry is situated at SH 621 650 in the historic parish and present community of Llandygai.

5.1.2 Underground features

Though Penrhyn Quarry was worked entirely on the surface, from the mid-19th century to 1965, it made use of water-balance shafts sunk through 'bastard' rock, to raise blocks and rubble from the pit to the processing areas. Two of these survive as surface features and are believed to preserve their subterranean features also. The growing depth of the pit and the prospect of using these devices led the quarry to complete a drainage level in 1849. Chambers of the drainage level were later used to house two, large, three-cylinder water-pressure engines installed by Easton and Amos in 1859 and 1872, driving a set of three large lift pumps in a shaft 37 metres deep. One remains *in situ*.

Significance category: AA

5.2 Tal y Sarn Slate Quarry drainage level PRN: 67449 NPRN: 546404

5.2.1 Location

Tal y Sarn Slate Quarry is situated at SH 4950 5329 in the historic parish of Llandwrog and the present community of Llanllyfni, on the north side of the Nantlle valley floor.

5.2.2 Underground archaeology

A shallow drainage level is accessible from a point south of the main quarry pit, and extends to the east and to the south of the pit. Part of a wheel-pit survives underground.

Significance category: AA

5.3 Cwmorthin Slate Quarry underground workings PRN: 67481 NPRN: 546407

5.3.1 Location

Cwmorthin slate mine is situated at SH 6805 4605 in the historic parish and present community of Ffestiniog.

5.3.2 Underground features

Cwmorthin slate mine worked the Back Vein and the Old Vein, divided by a drop fault running east to west. The site is managed by its tenants; the lower floors are easily accessible from a locked gate. Several floors are in use for adventure tourism, and whilst they contain few historic artefacts, provide a means of interpreting geology and slate mining techniques to visitors.

Other floors contain a wealth of historic features, including railway systems, wagons, inclined planes, the remains of compressed-air systems and walkways.

Significance category: AA

5.4 Llechwedd Slate Quarry underground workings PRN: 67451 NPRN: 546424

5.4.1 Location

Llechwedd slate mine is situated at SH 7001 4686 in the historic parish and present community of Ffestiniog.

5.4.2 Underground features

Llechwedd slate mine occupies an extensive area and was worked on many separate floors, but most of the site is currently inaccessible due to flooding (a persistent challenge on this site) and to rock-falls.

A number of levels are a*ccessible by the public* as part of the two visitor-attractions operated by the site-owner, an historical tour and 'bounce below', a trampoline experience of floor 2. The historical tour has involved construction of modern staircases and other access facilities. Access to part of the disused workings is possible by means of this floor, by proceeding along the level from the trampoline chamber on the same level. This leads to a pump-shaft and to the head of the New Ffridd incline, a well-preserved feature which enables access to chambers on floors A and B which retain good examples of underground features including a *caban*, cranes, stairways, underground tipping points and rail systems.

Significance category: AA

5.5 Maenofferen Slate Quarry underground workings PRN: 67460 NPRN: 546434

5.5.1 Location

Maenofferen slate quarry is situated at SH 7087 4651 in the historic parish and present community of Ffestiniog.

5.5.2 Underground features

Maenofferen slate mine occupies an extensive area, approximately 3.5 km²; along with its associated above-ground complex of buildings and infrastructure, it compellingly conveys not only the geology and technology of the industry but also its scale.

Part of the site is now inaccessible due to flooding of the lower floors and the collapse of bridges across chambers in the upper floors. However, the accessible parts are archaeologically extremely rich in that they illustrate the methods of mining slate and retain a wealth of artefacts, including well-preserved inclined planes and railways, compressed air systems, winches, *cabanau*, and a rising main. There has however, been considerable vandalism here, and theft of copper components.

Access to the mine is now only possible by making one's way down the back vein incline from surface.

Significance category: AA

5.6 Bryneglwys Slate Quarry underground workings PRN: 67497 NPRN: 546458

5.6.1 Location

Bryneglwys slate mine is situated at SH 6930 0530 in the historic parish of Talyllyn and the present community of Llanfihangel y Pennant.

5.6.2 Underground features

The accessible parts of the Bryneglwys mine include the workings in the Narrow Vein, to which access is possible from the 'Daylight level'. This leads to chambers on two levels, which preserve wagons and winches, but also form an instructive contrast with the adjacent open workings and with the chain incline system, illustrating technology transfer within the industry in the form of change-over from Nantlle-inspired systems in this near-vertical vein to Ffestiniog underground methods.

Significance category: AA

5.7 Aberllefenni Slate Quarry underground workings PRN: 67501 NPRN: 546470

5.7.1 Location

Aberllefenni Slate Mine consists of three distinct sites working the same vein of slate, at Foel Grochan SH 7690 1030 C), Hen Gloddfa (SH 7660 1004 C) and Ceunant Ddu (SH 7680 0990 C) in the historic parish of Talyllyn and the present community of Corris. These workings are located on the sides of a valley orientated north-east to south-west drained by the Afon Llefenni, which joins the Afon Dulas near the present village of Aberllefenni.

5.7.2 Underground features

The working method involves following a near-vertical vein downwards around a central shaft and lowering rock and tipping waste down the same shaft. This is unique to Aberllefenni and the smaller quarries of the Dulas valley, but has parallels with arrangements in the slate mines of the Loire valley in France and was unusual so much so that Clement Le Neve Foster, Britain's most pre-eminent Mine Inspector, wrote a paper on it in 1882. Hen Gloddfa has been accessed by specialists using SRT and is understood to have been largely cut off by a fall prior to 1866 and to preserve equipment from the 1840s or earlier in large vertical chambers, some of which rise to daylight over 150 metres above and are extremely impressive.

The Foel Grochan workings were accessed by levels which the lowest is now inaccessible. It was exploited until 2003 and has been recorded in detail. Numerous winches and haulage systems survive, including cranes, rail track, wagons, a cableway and a rocker shovel.

Significance category: AA

The project has also established that two sites proposed for inclusion in the World Heritage bid and known to have had underground workings and/or drainage levels are currently inaccessible, namely Pen yr Orsedd and Oakeley slate quarries in the Nantlle and Ffestiniog areas respectively. A short drainage level at Oakeley, the *lefel galed*/floor D-E, is understood to have collapsed recently, and the extensive underground workings at this site are subject to rock-falls.

We understand that one site proposed for inclusion in the World Heritage bid and known to have had underground workings is theoretically accessible but poses too great a safety risk to enter, namely Wrysgan Slate Quarry in the Ffestiniog area.

We understand that two sites proposed for inclusion in the World Heritage bid are known to have had drainage levels but that these are effectively inaccessible and have not been explored within living memory, namely Pen y Bryn Slate Quarry/Cloddfa'r lôn and Dorothea quarries, both in the Nantlle area.

6 CONCLUSIONS OF THE ASSESSMENT

The accessible parts of the seven sites identified in **5** above, are characterised by very high archaeological survival.

They are very different from their open quarry counterparts because of the high level of artefactual survival – not only cranes, bridges and other items, which were too big to remove or scrap, but also far more ephemeral ones such as candle stubs, newspapers and cigarette packets. The archaeologist is brought far closer to the world of the working quarryman in these places.

We conclude that the following seven sites merit inclusion in the WH bid as attributes of the slate industry of North Wales:

- Penrhyn Slate Quarry drainage systems and shafts (Ogwen valley),
- Tal y Sarn Slate Quarry drainage systems (Nantlle)
- Cwmorthin quarry underground workings (Ffestiniog area)
- Llechwedd quarry underground workings (Ffestiniog area)
- Maenofferen quarry underground workings (Ffestiniog area)

- Bryneglwys quarry underground workings (Bryneglwys Quarry, Abergynolwyn village and the Talyllyn Railway area)
- Aberllefenni quarry underground workings (Aberllefenni Quarry area)

7 MANAGEMENT

Management of significant underground sites pose specific challenges that are not found on surface sites.

7.1 Access

We note that access to these sites is comparatively easy, and that underground exploration in slate workings is now a well-established leisure activity. Experience shows that sealing up entrances and forbidding any access is highly unlikely to be effective, whether from the point of view of site owner, World Heritage site managers, Gwynedd Council or any other stakeholder. In places where strict security has been attempted, locks have been broken repeatedly, and even welded grilles cut through.

An effective instance of a private company that negotiates and manages access to underground sites on behalf of the caving and mine-exploring community is Cave Access Ltd. a company created to manage recreational access to various mines and caves, including on land owned by Natural Resources Wales.

Though this report has identified the most obvious means of access to each site, there are other means of access in each case, other than at Tal y Sarn Slate quarry.

Cwmorthin is the only site which is effectively controlled, by virtue of being locked on the most obvious means of access, and keys can only be obtained from the operator. It is currently regularly visited, probably on a daily basis.

The identified areas of Llechwedd can be physically accessed with comparative ease, and is managed by the presence of staff-members. It is occasionally monitored by J.W. Greaves staff.

The other sites are more challenging, and are only visited occasionally, by specialists. Bryneglwys is one of the sites managed by Cave Access Ltd, which makes available information about where to learn about the workings, and how to explore them. There is no permitted access to Maenofferen or to Aberllefenni.

As noted, the extent of each site that can be accessed might change, whether becoming more restricted because of rock-fall or flooding, or extended by exploration making its way into areas that are currently inaccessible. Management of each site will therefore need to take into account potential changes to the extent of the known archaeological resource.

7.2 Threats

The underground workings identified in this report are considered to be at risk from:

- Rock-fall (potentially all sites)
- Water ingress (particularly Llechwedd and Maenofferen)
- Surface quarrying (particularly Maenofferen and Aberllefenni)
- Theft of components and materials which fetch a high scrap value (particularly Maenofferen)

Maintaining the Outstanding Universal Value of these sites in the light of the risks identified here will require a robust management regime involving close and regular liaison with all stake-holders, and systematic monitoring.

7.3 Monitoring

Monitoring will need to be undertaken on a regular basis, to ensure that these sites have suffered no ill-effect from the threats identified above.

Current Cadw practice for monitoring scheduled monuments (a site-visit to each one on a rolling programme working over a ten-year cycle) is unlikely to be sufficient in the context of a World Heritage site, and will require some specialist skills. It may therefore be advantageous to involve specialist voluntary groups, or to contract monitoring to appropriately qualified individuals or groups.

Where Heritage Partnership Agreements are established between Welsh Government and site-owners in the event of a successful World Heritage inscription, monitoring arrangements will form an element of any such agreement. The main purpose of Heritage Partnership Agreement is to simplify arrangements for managing designated assets by reducing the need for multiple consent applications, thereby enabling regular maintenance to proceed according to agreed specifications as required.

7.4 Statutory protection

Statutory protection of underground features has been undertaken in Wales. Among examples where Scheduled sites explicitly include underground features are Ystrad Einion lead mine (CD143), Llywernog lead and silver mine (CD158) and the Great Orme copper mines (CN216).

Historic England's *Designation Scheduling Selection Guide Industrial Sites* notes:

> While it is legally possible to schedule industrial workings below the surface of the earth, in practice very few have been designated in the past. Considerable challenges arise over their long-term sustainability. Mining played a fundamental part in the Industrial Revolution, but only in carefully selected instances will below-ground scheduling be appropriate.

Historic England's *Designation Scheduling Selection Guide Transport Sites* notes:

> However, difficulties in mapping underground remains – often complex and three-dimensional – can often constrain designation aspirations. Nor will scheduling necessarily be appropriate even if the remains are deemed nationally important; other management options may be more beneficial. Careful consideration will be needed on a case-by-case basis.

The present document has considered the underground archaeology of the slate industry of North Wales, and concluded that it is of national and international significance. Any scheduling which takes place within these areas will require clarity about what is scheduled, and where the scheduled areas are located. Scheduling brings with it the protective measures of the 1979 Act (as amended by the 2016 Historic Environment Act [Wales]). These include the powers to control works within the scheduled area and to deal with damaging activities including powers to prosecute and/or enforce

repairs. A particular challenge will be the level of protection this confers on portable and removable items.

7.5 Conservation and recording

Conservation and further recording of underground features within the slate industry of North Wales are matters which lie beyond the scope of this report, but will need to be considered as the bid is developed. A priority will be a 3-D modelling of these sites, with a view to locating and identifying features within them, and establishing lower and upper horizons for Scheduled areas. Options include co-operation between RCAHMW and mine explorer groups or participants on courses at the SNP study centre, involving laser-scanning and total station survey. A pilot project carried out by RCAHMW would identify possibilities.

Conservation of individual features may be necessary but should be carried out on a case-by-case basis with a strong presumption in favour of items remaining *in situ* and in context.

7.6 Developing relationships

It is recommended that any management regime instituted in anticipation of a World Heritage nomination will need to develop effective relationships not only with owners but also with mine exploration groups, and to make effective use of social media. Owners and any such groups should be consulted on the management priorities for an underground World Heritage site.

8 RECOMMENDATIONS OF THE ASSESSMENT

We recommend that:

Gwynedd Council continue negotiations with the owners of the sites identified in **5** with a view to confirming their agreement that the identified underground features form part of the Slate Industry of North Wales World Heritage bid.

Gwynedd Council through the medium of the Slate Industry of North Wales Conservation sub-group discuss with Cadw appropriate levels of statutory protection for these sites.

Gwynedd Council through the medium of the Slate Industry of North Wales Conservation sub-group and maintaining close liaison with all stake-holders, ensure the preparation of a comprehensive and robust management plan for these sites.

In order to ensure an appropriate management plan, we further recommend that:

Gwynedd Council through the medium of the Slate Industry of North Wales Conservation sub-group discuss with RCAHMW a pilot project to record selected locations within the sites identified in **5**, with the ultimate aim of carrying out comprehensive recording

Gwynedd Council continue negotiations with the owners of the sites identified in **5** with a view to developing appropriate management regimes for these underground features.

Gwynedd Council initiate negotiations with mine-explorer groups with a view to developing appropriate management regimes for these sites.

Gwynedd Council initiate negotiations with mine-explorer groups with a view to developing appropriate management regimes for these underground features.

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