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WATER POWER IN THE SLATE MINES OF EAST FFESTINIOG

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Abstract: This paper is a study of the Bowydd water supply system, east of Blaenau Ffestiniog town centre, and its use by three slate mines Votty, Llechwedd and Maenofferen. It is, primarily, an analysis of physical remains that are threatened by modern quarrying. Descriptions of recently-destroyed structures and features are drawn from our mid-1980s study of the Votty & Bowydd Slate Quarry prior to a 'land reclamation' scheme.

Introduction

The district centred on the town of Blaenau Ffestiniog, Gwynedd is famed for its blue-grey roofing slates and slate slabs, which are found in four main beds known as the New, Old, Back and North Veins. Although local builders worked small, thick slates from surface exposures from time immemorial, the commercial origin of the industry in this locality dates from the 1760s. A number of quarrymen from the long-established slate workings at Cilgwyn, in the Nantlle Valley, ventured south to exploit a promising rock exposure at a location known as 'Ceunant y Diphwys,' - the Diffwys Gorge (see Lewis & Williams 1987).

Although the precise location is lost due to later intensive quarrying, the site of this mother quarry of the Ffestiniog slate industry has generated much speculation. Modern quarrying at Diffwys has cleared away old debris heaps, allowing a view of the original land surface. This new evidence suggests that the gorge on the Diffwys stream was on the south side of the present 'Lord' opencast pit, where the lower levels of the Diffwys Quarry merge with the upper workings of the old Bowydd Quarry.

The slate industry at Ffestiniog grew rapidly in scale from the first quarter of the 19th century, with a plethora of new quarries being opened by budding entrepreneurs who ranged from aristocracy to the local innkeeper. Buoyed by reduced transport costs with the opening of the Festiniog Railway (sic) in 1836 and the development of a valuable export trade to Germany from 1842, the district's slate industry boomed in the 'slate rush' of the 1860s-70s. This rapid development created the new town of Blaenau Ffestiniog and the characteristic quarrying landscape that surrounds it (Lindsay 1974; Gwyn 2002).

The three quarries/mines of Llechwedd, Maenofferen and Votty & Bowydd included in this present study can be placed high amongst the second rank of slate operators in Gwynedd. More diminutive individually than the mighty Penrhyn, Dinorwic and combined Oakeley quarries, they were on a par with the Alexandra, Dorothea Penyrorsedd and Talysarn quarries in the Nantlle district (Jones 1996). This upper second rank grouping is characterised by an annual late 19th century output of around 10,000 to 20,000 tons, and a workforce averaging 300 to 600 men.

The Votty and Bowydd Quarry

(Colloquially 'Lord') combines two early 18th century sites opened on land owned by Lord Newborough (Glynllifon). Both small quarries were worked sporadically in the early 19th century, but successful development did not commence until the arrival of the young entrepreneur, John Whitehead Greaves of Barford, Warwickshire, in 1833. The exploitation of the major slate reserve, beyond the disturbed geology just east of the old opencast Bowydd Quarry (or 'Lord pit'), was the achievement of the Percival family of Northampton. They, latterly with others, were the lessees from the 1850s, and retained control of the works until its sale to the Oakeley Quarry Company in 1933. Closed in 1962 due to unprofitability, the Votty mine was subsequently sold to the adjacent Maenofferen Quarry as tipping ground, reopening on a small scale as an opencast pit under Llechwedd Quarry's control in the mid-1980s.

Maenofferen Quarry

Located on Newborough land east and up-slope of Votty, this was an outlying trial working of the old Bowydd Quarry but became an independent concern in the 1860s (Lewis & Williams). Its long-lived operating Company (incorporated in 1862) lasted until 1971 when it was sold to the Llechwedd Quarry. Underground working continued at Maenofferen on a small scale until the 1990s, when operations at the mine became very sporadic. Today, some extraction is being undertaken in an old open-cast working ("David Jones' pit"), the probable site of the original trial workings.

Llechwedd Quarry, another 'child' of Votty, lies over the shoulder of the hill to the north east of the mother quarry. It was first opened in 1846 by J.W.Greaves, at a location now occupied by the 'Quarry Tours' slate museum. Greaves bravely forsook Votty in favour of his new venture and, after a nail-biting initial trial, struck lucky (Wynne Jones). A substantial mine with several open-cast 'sinks' was developed on this site and, although the underground operations ceased in the 1970s, significant opencasting continues. Llechwedd's original lease boundaries overlapped portions of three landed estates causing inconvenience and costs on occasions. However, the leasing of the northern fringe of Lord Newborough's land on the ridge above Votty was very fortuitous for the Llechwedd concern, in that it provided access to the extensive Bowydd water system and upon which that quarry still relies.

Quarrying Methods

The dip of the slate beds in relation to topography has dictated quarrying methods throughout the industry in north Wales. Although the first workings in the Ffestiniog district were opencast such as the large Bowydd/'Lord pit' - the dip of the slate under massive beds of 'granite' (or gritstones) encouraged extraction by mining from early in the 19th century. From early caverns supported by rock pillars, the Ffestiniog 'chamber and wall' system of huge subterranean caverns evolved (see Isherwood 1988). Although 'untopping' costs were negligible in these combined quarry/mines, vast reserves of workable slate rock had to be left as walls supporting the roofs of the 60 ft. average width chambers. The slate in these supporting walls proved too tempting for several mine owners, resulting in

major collapses of ground, such as at Votty in 1899, where several chambers collapsed in the Old and Back Vein workings on floors A, B and C in the still-inaccessible area beyond Chamber 6.

Today, the underground extraction of slate has ceased completely because modern earthmoving plant has made the removal of the 'tops' convenient and cost-effective allowing the quarry owners access to the old chamber walls which average 40ft. in thickness and several hundred feet in depth.

Production Methods
Slate slabs extracted from the rock face were originally reduced in size, split and the sheets dressed to shape, out in the open on the quarry bank, a flattened area of spoil tip just outside the workings. When quarrying became a full-time occupation rather than a profitable side-line from farming, wet-weather cover became necessary for those engaged in the splitting and dressing operations in the form of simple huts (termed gwaliau) built of waste slate blocks (Jones 1996).

Mechanisation of the production processes required larger buildings to cover the sawing and planning machinery, firstly introduced for producing slate-slabs and, from about 1852, for the manufacture of roofing slates. By 1860 the standard design of an 'integrated' mill had been constructed at the Diffwys Quarry, the first of scores erected throughout the Ffestiniog district and beyond. Llechwedd Quarry ultimately had 6 mills; Maenofferen and Votty each had 5 mills (one being shared), although not all were in use simultaneously in the individual quarries (Jones et.al; Lewis Tyb).

Power Sources
In common with metal mining and other early industries, the slate mines of Ffestiniog made as much use of water power as was possible. Water was a cheap option once the infrastructure had been erected, assuming that the rights of supply and usage could be secured inexpensively.

The climate of Blaenau Ffestiniog benefited the use of water power in its slate quarries by being the "home of rain". High precipitation was, however, of little value unless the topography was also favourable for the erection of storage reservoirs convenient for the delivery of the water to the user.

This is well illustrated by the Diffwys Quarry workings, located immediately south of Votty. Prevented from using the Bowydd catchment by not being on Lord Newborough's land, Diffwys had to utilise steam power for an uphaulage surface incline of the 1850s and three large processing mills of 1860-1865, because there was very little scope for water collection and storage within the quarry's boundaries (Lewis TyB). In contrast, the nearby Votty, Maenofferen and Llechwedd quarries were able to tap the water reserves of the Bowydd catchment area by leasehold from Lord Newborough.

Despite its economic advantages, a reliance on water power had its negative side. Summer droughts and winter freezes (colloquially termed 'smit' a term of unknown origin) could, and did, diminish the available supply with damaging effects to the production process. Excessive prolonged rainfall could also create havoc through the overflowing of watercourses and reservoir dams, causing damage to their fabric. Moreover, as the scale of working increased a greater daily supply of water was required forcing the quarry owners to invest in larger and more sophisticated catchment and storage systems.

This is a convenient juncture to consider the hardships endured by the men employed or, more prosaically, entrusted with the operation, care and maintenance of these water systems. Although the normal day's work was the cleaning of culverts and the opening/shutting of valves and floodgates, this small band was on-call at all times, being required to "head for the hills" in atrocious weather to deal with emergencies.

By the second half of the 19th century, this mismatch of water supply and power demand in the larger quarries was instrumental in driving the trend towards converting essential services such as the main winding inclines and pumps to steam power. Coal brought in to Blaenau Ffestiniog by rail was at its most cost-competitiveness as a fuel, and the modern 'semi-portable' steam engines were more efficient than their cruder predecessors. Thus, by the late 19th century, back-up units were sometimes obtained for water-powered services, e.g. the provision of a 16 hp 'Robey' undertype engine on standby at the Votty floor C mill.

Notwithstanding the temporary ascendancy of steam power, it was the introduction of electricity to the quarries at the turn of the 19th century that triggered one of the greatest technological changes in quarry plant. Electric motors rapidly replaced waterwheels, water-balances and steam engines in the larger quarries in the three decades after the first local experimental use of this new source of power at Llechwedd in the early 1890s.

The prime power source for much of the early individual electric systems used in the Ffestiniog quarries was, however, the same water systems that had previously turned the wheels and filled the balance tanks. Even the imported 3-phase AC. 'mains' supply (of 1906) of the North Wales Power Company was hydro-generated, at Cwm Dyli near Beddgelert.

The first large scale electrification of a slate quarry in north Wales was at Votty in 1899-1900, under the direction of T. Osborne Yale, whose hydro-electric scheme for the Dorothea Quarry, Nantlle, had just fallen through (Jones 1980). The Votty Company formed the Yale Power Co.Ltd. specifically for the project that was initially costed at £6,000. A hydro-electric station was erected at Dolwen, west of Blaenau Ffestiniog, and the DC power was transmitted overhead to the Votty quarry via a secondary power station at Dolgarregddu, near the middle of the town. The extra power station contained a 100 hp gas engine and two semi-diesels, generating an additional 240kw of power that was distributed to the town when not required by the quarry. Another 48 kw booster set was also needed at the quarry to counter the voltage drop inherent in the system.

The Llechwedd Quarry installed a pair of pelton-driven DC. generators in 1904, utilising the significant height difference between the reservoir above floor No.7 and the valley floor at Pant Rafon. This plant was later supplemented by a standby vertical oil engine set.

Maenofferen did not electrify until c.1910, when a small DC pelton turbine-driven generator, with standby steam engine was installed on the hillside west of the quarry mills. Little is known of this plant. The steam engine was removed by the 1920s and a 3-phase AC back-up supply obtained from the North Wales Power Company, although this required rectifying for the old motors still used at the quarry until recently.

Power Plant
The different tasks required of power sources in the slate mines in the 19th century can be divided into three main functions: winding, pumping and mills. In the 20th century,

air-compressing and electric-generating were added to the above task list.

Winding of material out of the early opencast pit was originally achieved using hand winches (turntrees) and horse winches (whimseys). When greater uphaulage was required and water was available, water-balance inclines became popular. A rail-mounted water tank consecutively filled at the top of a slope and emptied at the bottom, could haul a wide-gauge transporter car carrying up to two loaded quarry wagons (say 8 tons in total) up a second rail-track, as at the C-B and B-A floors 'lifts' at Votty (see Newcomen 1938; Lindsay 1974). Another single-acting balance incline serviced the floors 2 and 3 Back Vein workings at Maenofferen prior to the installation of the Chamber 1 Back Vein steam incline ('Inclên Idris').

The efficiency of these balance inclines could be increased by making them double-acting, whereby a pair of combined transporter/tank cars were used, as at the 180ft high Votty floor C, Diffwys floor 0 balance, and the even longer floor 2 to 6 balance at Llechwedd. Vertical shaft balances were more rare in the industry because of the capital costs involved, although there were two at Ffestiniog and one each at the Oakeley ('Bonc Shaft') and Rhiwbach quarries (Gwyn 2000).

The disposal of the discharged "waste" water from these balance lifts limited their usefulness for underground haulage below the drainage adit although surface water-wheels could be used instead (such as the remote 'Olwyn Goch' the Red Wheel above Llechwedd No.7 floor). The development of the characteristic multi-tracked haulage inclines at Ffestiniog coincided with a requirement for greater power and speed, thus favouring steam power (Isherwood 1988).

Consequently, new main haulage routes at our three featured quarries in the late 19th century were exclusively steam powered, and those which remained in use in the twentieth century were subsequently electrified. These steam-powered main inclines are worthy of listing, if only to demarcate some of the non water-powered haulage systems. They were the floor 5 centralised winder at Llechwedd; the 'Old Robey' (Old Vein) and 'New Robey' (New Vein) winders at Votty; and the two Old Vein and the Chamber A1 Back Vein ("Inclên Idris") inclines at Maenofferen. Other, newer, electric inclines were added as required, such as the Maenofferen B31 Back vein, which with the A1 were the last in use in the district.

No reference to, or physical remains of, water-powered 'aerial' haulage has been discovered in the Llechwedd/Maenofferen/ Votty area, with the caveat that details of the last location in particular, are very sketchy before the 1860s.

Pumping from slate quarry workings generally adopted metal mining practices. It is thought that a 'Tom & Jerry' reciprocating 'cistern engine' operated at the Rhosydd Quarry in the 1830s (see Lewis and Denton 1974) and such plant may also have been used in the east Ffestiniog quarries in their early years of work. However, the general trend in the slate industry from the early 19th century was the use of water-wheels powering simple bucket-pumps via reciprocating rods. The water was raised to drainage adits that frequently doubled as haulage tunnels

Sometimes, when the distance from the wheel to the pump was great, or where the drive path was indirect (as is believed at the Olwyn Goch, Llechwedd), rigid sweep rods were replaced by wire rope. In the latter case the upward (water-raising) stroke of the pump was achieved with the wire under tension from the pull of the wheel crank and suitable weights on the pump actuating rod provided the return (unloaded) stroke (Jones 1996).

The combination of slow speed and high torque made water-wheels the ideal power sources for reciprocating pumps. Unfortunately, the increasing depth of the larger mines by the late 19th century required stronger pumps of a greater capacity than before. This situation was exasperated at several quarries by surface water percolating into the mine through roof fissures caused by major rockfalls that were plaguing the slate mines by the end of the 19th century.

Consequently, steam-powered pumps became favoured in the deepest Ffestiniog mines until the advent of electric plant at the turn of the 19th century. Votty, having a relatively light pumping load, used a secondary reciprocating drive off its 'Old Robey' (c.1876) winding engine to raise water from the developing deep workings (reaching at least floor G, pre-1900) up to the discharge tunnel on floor C.

The arrival of electric power heralded the rapid demise of the steam units, with mines installing compact centrifugal or small three-throw pumps, raising water in short 'lifts' of one or two floors. By using this tandem pumping method, involving intermediate sumps (termed 'looms') located in dammed worked-out chambers, the capacity (and thus running costs) of individual units could be matched to the actual pumping load at specific locations.

An unusual pump - the water ejector - not found elsewhere in the slate industry, was used in two of the Ffestiniog mines. One was at the Rhosydd mine (see Lewis & Denton 1974) and the other at Votty, the latter machine being claimed as the largest of its type ever built. Installed in 1931 to replace an electric pump on the final 'lift' to the drainage tunnel, this product of Glenfield & Kennedy of Kilmarnock was designed by the Hydrautomat (1931) Ltd of London. High pressure feed water was forced through an inverted nozzle in the pump's suction chamber, with the resulting venturi effect being sufficient to raise both feed and pumped water up a significant distance at zero operating cost. The 'Hydrostat' pump was installed on floor D and was fed by a 12-inch pressure pipe at a rate of 500 gallons per minute from the flooded old Hafoty pit (on floor 2) a vertical distance of some 150 ft. The machine pumped water from the D 'loom' a height of 60 ft vertically to the outlet adit on floor C at a rate of 1,420 gallons per minute in addition to removing its own feed water (Hughes 1938).

Slate processing mills were most commonly long buildings having saws, planers and dressing machines powered by pulleys and flat-belts from a system of line-shafts. The preferred prime mover for mills at Ffestiniog was a geared water-wheel of up to 45ft diameter, a design of plant which provided a steady torque to the mill shafting. In certain cases, as at the second Maenofferen mill (of the 1870s), a turbine was preferred as prime mover, possibly a choice dictated by the topography of the site.

Where insufficient water was available there was no choice other than process off-site (in early era) or use steam power. Although one case of standby steam power has been noted (see above) for a mill in one of our featured quarries, this cannot be ruled out in other sites. In most cases, however, steam was never involved and water-wheels were replaced by electric drive when this became available. Nonetheless, it appears that this was generally only done after the electrification of pumps and winders - plant with the highest running costs. Thus,

despite being provided with electricity by the Yale Power Company in 1899, the waterwheels of the Votty mills were apparently retained until 1912.

Description and history of the Bowydd water system

The major source for the water power for the three featured quarries was the catchment area of the Bowydd river a tributary of the Dwyryd (the main river of the vale of Ffestiniog). Arising as minor streams in the miles of boggy plateau east of Blaenau Ffestiniog, two main feeders joined on the hillside just to the east of the present Maenofferen upper workings. A shallow rivulet in summer, it is a wild torrent in prolonged wet weather.

From this confluence, the infant river Bowydd meandered over mini-cascades until the steepening hillside prompted the cutting of a gorge, lost long ago under the Maenofferen slate waste heaps. Passing through the site of the present Votty tips, the river Bowydd subsequently flowed away out of the study area through a covered culvert under part of Blaenau Ffestiniog town.

Few documentary references have been seen relating to the abstraction of water from the Bowydd system by the early workings at Votty and later by the Llechwedd quarry. Perhaps the remains of a small reservoir in the Maenofferen gorge was the pentstock for the leat supplying only the first Votty mills on floor 1 and floor 'half'. If so, then this was surely fed from a tributary stream which had once poured out of a highly-visible culvert under the top of the Rhiwbach tramway No.2 incline, which ascends the north side of this gorge.

Another early documentary reference of August 1865 refers to "water used to work the incline at Lord" having been used to work the mill at the Diffwys Quarry instead. The complete significance of this statement has yet to be understood.

Llyn Bowydd water, Votty abstraction system

It is very possible that Votty alone constructed the first system to abstract a substantial amount of water from the main Bowydd catchment sometime in the mid 19th century a time when its scale of operations was enlarging.

A possible original small lake near the south-eastern boundary of Lord Newborough's land was enlarged by means of a low masonry dam, which found a dual use as part of the trackbed of the Rhiwbach tramway (of 1863). The initial role of this reservoir, named 'Llyn Bowydd' was to entrap water that could be released under control into the Bowydd river, from whence it was abstracted for use by the quarry.

The Rhiwbach tramway wayleave plan of 1860 (Dolgellau), although not concerned with water systems, does show some details of the layout of the streams and leats. The main feature was an artificial watercourse directing water from Llyn Bowydd along a high level course to a point just west of the old abandoned Hafoty opencast pit, which in later years became a reservoir. It can only be speculated what use was made of this leat. Was the watercourse a now-lost feeder for Llechwedd quarry, or was it directed into the Hafoty pit from the western end? The answer remains unknown for the present, but it is certain that by the 1890s this watercourse had been redirected to the Cyfiawnder pool, described below, and thus its flow was in later years divided between Votty and Llechwedd.

Cyfiawnder watercourse

Not shown on the 1860 tramway wayleave plan is the joint Votty/Llechwedd lower watercourse, which existed by 1881, and which probably dates from the 1870s. This abstracted water from the river Bowydd in the Maenofferen Gorge, taking it along the contour to the ridge-top marking the Llechwedd boundary. Its first length, located on the side of a steep escarpment, was constructed in timber, and the slate block pillars that supported the launder are still visible below the embankment of the Rhiwbach tramway. The latter part of the route involves a tunnel that replaced an earlier course, where the narrower profile of the dry ditch shows that the whole system has been enlarged at some date.

Once on the ridge, the flow was divided equally between the two quarries by means of a stone shaped like the base of a 'steam iron', and consequently termed the 'heater stone' in English. The Calvinistic Methodist inspired Welsh name is more prosaic "Y Cyfiawnder" ('The Righteousness').

From the Cyfiawnder pond, one feeder ditch ran directly to the upper Llechwedd collection reservoir named 'Llyn Fflags' because its low dam was partly built of vertical slate slabs. Topped up by water from a long watercourse abstracting from the new reservoir on the river Barlwyd to the north-east, this augmented supply then fed the Llechwedd balances and water-wheels with the exception of the remote 'Olwyn Goch' wheel. In 1904 Llyn Fflags became the pentstock for Llechwedd's hydro-electric station, located adjacent to the mouth of the London & North Western railway tunnel.

The Votty half of the Cyfiawnder water was taken to a small holding reservoir forming the penstock for the complex system of timber leats that served the quarry's mills and balances at a maximum rate of 350 cubic ft per minute. Using a tandem arrangement of plant, with feed-back branches, this water worked the Floor 1 mill wheel; Floor half writing slate mill 25ft x 4ft wheel; Floor A mill 35 ft. x 4ft wheel; Floor B mill 40ft x 3.25ft wheel; Floor C mill 45ft x 4ft wheel; the A/B and B/C balance inclines; and a separate branch worked the big double acting C/floor half water balance. Falling five working levels this water probably did the equivalent of 200 hp of work.

Llyn Newydd

At a date post-1863 and prior to 1882, a weir was constructed across the second major feeder stream of the river Bowydd, forming a new reservoir called unimaginatively 'Llyn Newydd' (New Lake). It appears, from reading between the lines of later correspondence, that the cost of building this reservoir was shared equally between the Llechwedd, Maenofferen and Votty companies, as all three concerns benefited from the additional holding capacity of the water system during an era when the power demand was also increasing.

The Votty Company obtained costings in 1882 for increasing the height (and thus storage capacity) of Llyn Newydd, with an alternative scheme to build a new reservoir on the outlet of Llyn Bowydd. Neither proposal came to fruition, probably as the result of dissent amongst the other contributors. When the Llyn Newydd expansion was resubmitted by Votty for consideration in 1896 surviving correspondence shows polite animosity to the idea from Maenofferen, and benevolent indifference from Llechwedd, neither of which needed more water. The dam was eventually raised by 3ft giving an extra capacity of 12,469,700 gallons, equivalent to five days use by Votty. Llechwedd promised to contribute to the cost, but it is not known whether Maenofferen did likewise (Dolgellau).

Maenofferen water abstraction

The Bowydd River was, prior to 1881, diverted following the

contour around and above the Maenofferen workings to prevent flooding of the deep mine. As an added insurance, a drainage level was also driven parallel to the old river course, to divert upper ground-water away from the pit. Part of this drain was latterly piped, using redundant bomb-cases.

The river's diverted course provided the required height both for a pressure-head for a turbine powering the new middle mill, and for a high-level timber aqueduct serving the 40ft diameter waterwheel of the new large mill (all on floor 3). An earlier supply system had individually fed the floor 2 - 3 balance incline and the water-wheel of the first Maenofferen mill. To ensure a sufficient flow of water in the Bowydd river for the use of Maenofferen, and also for the Votty timber watercourse, several overflow weirs and adjustable gates were installed in the Llyn Bowydd/Newydd diversion leats.

The abstraction from the Bowydd diversion, if unregulated, would have diminished the amount of water available for the Votty/Llechwedd timber watercourse. However, the tailraces of both the old mill water-wheel and turbine debouched directly into the Bowydd above the Votty take-up point. This could not be achieved for the tailrace of the new large Maenofferen mill, therefore its outflow was carried by timber leat over the gorge to join the Votty troughs. It is assumed that this arrangement was a result of a multi-party water-rights agreement, of which nothing is known at present.

The final modification to the supply system was carried out at the instigation of the Maenofferen Company. Requiring a pressure head for its new hydro-electric station, located on the Llechwedd boundary, a new high-contour covered leat (but piped around rocky bluffs) was built c.1910. Although this arrangement tapped a substantial amount of water from both Llyn Newydd and Llyn Bowydd, by this date Votty was much less dependent on water power, and the tailrace from the generator's pelton (later a 'Turgo') went directly into Llechwedd's top reservoir feeder stream.

This scheme involved a short diversion of the Llyn Newydd watercourse around the upper side of the power station. However, the stream has since broken out of its watercourse and has recaptured its earlier path to the 'Cyfiawnder' pool.

In the Later Days

After World War 1 Votty only required a minimum amount of piped water for cooling the saws, drinking, and for flushing the latrines. The quarry's interest in the water system had changed from that of water supply to that of flood prevention. The Bowydd river gorge was now filled by waste tips, and the 1899 rockfall had caused an inroad of water into the Votty deep workings. Thus the Bowydd river in the gorge was culverted to confine the flood water. Unfortunately, severe weather in the 1940s and the late 1950s caused great and expensive damage to this culvert. With the workings reaching down to floor M (9 floors below drainage adit) water pumping at Votty was becoming expensive enough without the extra surface water getting in, and this inevitably contributed to the decision to close the mine in 1962.

Maenofferen by the 1920s, became only interested in its hydro-power station leats, and in preventing surface water penetrating into the mine, particularly inflow through the upper opencast pit. This protection of its operations possibly involved subterfuge as Votty's management became very suspicious of the carefully engineered "natural" drainage holes which appeared in strategic locations at Maenofferen.

Llechwedd remained able throughout to obtain all the water required for its hydro-station via the Maenofferen power station outflow, the Llyn Newydd leat, and also its alternative sources from the Barlwyd catchment to the north-east.

Conclusion

Additional historical information undoubtedly lies untapped within deposited (and retained) quarry company papers, and in the voluminous Newborough (Glynllifon) manuscripts. However, site recording must take precedence in the Ffestiniog slate quarries as the physical evidence is the most fragile research resource in this age of heavy earthmoving machinery.

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