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CONCLUSIONS: OVER TWO THOUSAND YEARS OF WATER POWER

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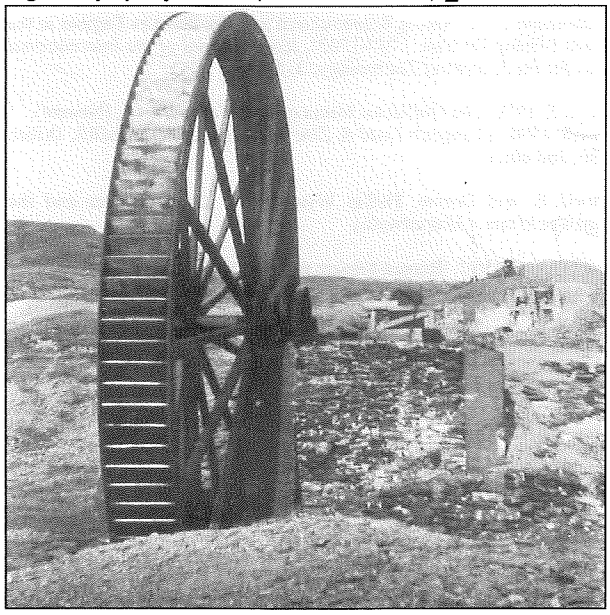
Large, narrow breast, waterwheels were once a common sight on the lead-zinc mines of mid-Wales, utilising a surprising scarce water resource to advantage in an upland area where a significant fall in water level allowed for wheel up to 63 feet in diameter. (Williams, this volume) To many mining historians in Wales that period, the mid to late 19th century, was the heyday of water power. It left us with many features, the wheel-pits and extensive leat systems, which can be interpreted in relation to the development in deep mining at the peak of recorded production (Bick 1976, 40-47; Stephen Hughes, this publication). However, the papers presented here make it clear that water power has been used effectively in European mining for over two thousand years.

The full purpose of the water leats in evidence even today at Dolaucothi, near Carmarthen in south Wales, remains uncertain (Ancel, et al. 2000). There is, nevertheless, archaeological evidence that water was probably applied there for working a stamps mill, used in ore preparation, in the early Roman occupation period (Burnham 1997, 332) and, as Timberlake has shown (this volume) there are indications that water was used for hushing for prospecting purposes in Wales at that period. The availability of water power at Dolaucothi would, however, reflect the skill with which it was applied elsewhere in the Roman Empire (Bird, this volume). Using the surveying techniques that allowed them to bring water over considerable distances, Roman engineers provided sufficient hydraulic power to cut into the sides of mountains, not only through placer deposits but also assisting the removal of hard rock ore deposits. We should, however, be careful not to make too direct a comparison between the features to be seen in northern Spain and those at Dolaucothi without first ascertaining the scale of mining when the Romans arrived; only then can we perhaps gauge the effective use made of water power.

It was not until the late medieval period that water was again used on the scale found under Roman occupation. Hushing, as a means of working the outcrop of metalliferous vein deposits, was to be a feature of the Pennine uplands of England from Wensleydale northwards in the 18th century; but its use as a prospecting tool may have continued, if only in Wales, through the early part of the medieval period (Timberlake, this volume). Waterwheels, applied directly to mining, appeared in the second half of the 15th century although they had been used in ore processing, as the power for smelting and refining mills, for at least two centuries. The water powered pumps, installed in the silver mines at Bere Ferrers in south Devon by 1480, lacked the later advantages of power transmission and required an early revival of the surveyors' skills to bring water over 16 kilometres, from one river catchment into another, to a wheel positioned directly over the pumping shaft (Claughton 1996). Such pumping, and later winding, wheels with their associated leats had been introduced at a similar period for the deep working of silver-bearing ores in Central Europe and Siems (this volume) has shown how elaborate the systems were to become in the Freiberg district. By the 16th century those mines, like the silver mines in England, benefited from central management and the ability to plan for capital investment in water power. They were also deep mines where drainage and haulage were beyond the capabilities of manual labour.

The introduction of water-powered mechanisation in mining in the late medieval period had been stimulated by the increasing real cost of labour in the century and a half following the Black Death (Claughton 1994). In the 17th and early 18th centuries, as the population once more grew steadily, there was competition from cheap labour and it is not unusual to find quite deep metal mines, in areas well placed to adopt water power, being pumped entirely by hand (see, for example, Bick and Davies 1994; where manually operated pumps are depicted on most of the mid 18th century mine sections).

Fig. 1. Bryn yr Afr, 1932. (D.L. Dixon Colln).



Whilst the economics of water power are not addressed directly in this volume, it is relevant to any historian considering its application in mining and warrants some detailed research. With the development of steam engines there was a powerful alternative to water, yet even in the coalfields water power continued to be used well into the 19th century. In some fields the coal, like the anthracite of Pembrokeshire in the western part of the South Wales coalfield, was not suitable for steam raising before improvements in boiler construction but, as Stephen Hughes (this volume) illustrates, even where suitable coal was being mined water was used until 1803. For mining fields remote from developed coal production there was little alternative to water power but once there were improvements in transport, for example, the spread of the railway network in Britain during the second half of the 19th century, there were pressures to adopt steam power. It is not surprising, therefore, that the advances in water power were made in those mining fields where, even in the late 19th century, the fuelling of steam power was still an expensive option. Developments in the new mining fields of the American west brought water power, through the impulse turbine, a new dimension - the generation of electricity (Kraft; Kirshenbaum and Brechin, this volume) and an economic advantage with world-wide impact.

Water power, using wheels and extensive leat systems, had become common place in the metal mining fields of Britain from at least the mid 18th century. Enabled by a new breed of commercially aware mineral lords, and the consolidation of mineral leasing, from the late 17th century onwards, the scale of development seen at Grassington (Gill, this volume) was to be found across the uplands from Cornwall to Yorkshire and into the Northern Pennines. In the latter field, under the supervision of engineers like Forster and the Westgarths, water power was developed to good effect on a grand scale. Advantage was taken of the available head of water in the early development of the water pressure engine. Similar developments were also taking place in central Europe from Saxony (Siems, this volume; Bartels 1997) to the Adriatic - see, for example, the surviving 13.6 metre pumping wheel, dating from 1790 at the Idrija Mine in Slovenija. Those large narrow breasted wheels which dominated the mid Wales ore field were the culmination of over four hundred years of development. The water pressure engine on the other hand was a product of the late 18th century and was perhaps at the height of its popularity in the mid 19th century. Carlisle and Gill (this volume) have provided us with an illustration of the diverse nature of its application in Swaledale at that period. It is perhaps not surprising that pressure engines provided the motive power in the last attempt at deep working in Gunnerside Gill. Their survival in the Sir Francis Level helps illustrates the need to examine more than just the engines, important as they are for mining archaeology, and consider their infrastructure and the mines that they served (Roe, this volume).

Of the other forms of water power we have touched only briefly on water balances. Using the weight of water to lift tram wagons of coal to surface, these devices were commonly found in the valleys of the South Wales coalfield, although they did find limited uses elsewhere, in some of the north Lancashire and Cumberland haematite mines, in the Lancashire coalfield, and at the Bideford Anthracite Mine in north Devon. They were however were best suited to sites where the topography allowed water to be exhausted by adit at depth (Evans 1862). In slate quarrying such methods did have an advantage for powering surface inclines where the water was reused for further processes at a lower level (Jones and Dafis, this volume).

The rapid development of new dimensions to water power in the mining fields of the American west was enabled by the abandonment of earlier practices which had their origins in antiquity. Having the benefit of an infrastructure built to serve hydraulic mining certainly gave California a head start in developing the water turbine, coincidental with the use of electricity for power transmission. Experimentation led to greater efficiency in turbine design (Kraft and Samay, this volume) and, with mining enterprise ready to adopt the new techniques (Brechin and Kirschenbaum, this volume), it was rapidly diffused to other fields. By the turn of the 19th century it was displacing the conventional waterwheel in mid Wales (see Bick 1996, 50-52, for the new plant installed at Frongoch).

The ancient hydraulic application is now again being taken forward in mining. Mining coal by hydraulic methods may have had only a limited success (Summers, Hydraulic Mining, this publication), but as to its recent application for drilling purposes (Summers, Whither Water Power, this volume), we are probably seeing only the beginning of its real development with impact on more than just the economics of mining.

One aspect of waterpower is therefore self evident; it is still a significant player in the application of power in mining. Water turbines continue to hum on mine sites world-wide, providing electrical power, and water jet technology is at the forefront of the drive for greater efficiency and safety in mining. Steam power may have come and gone; large elegant waterwheels may now be museum pieces; but water remains a power in mining.

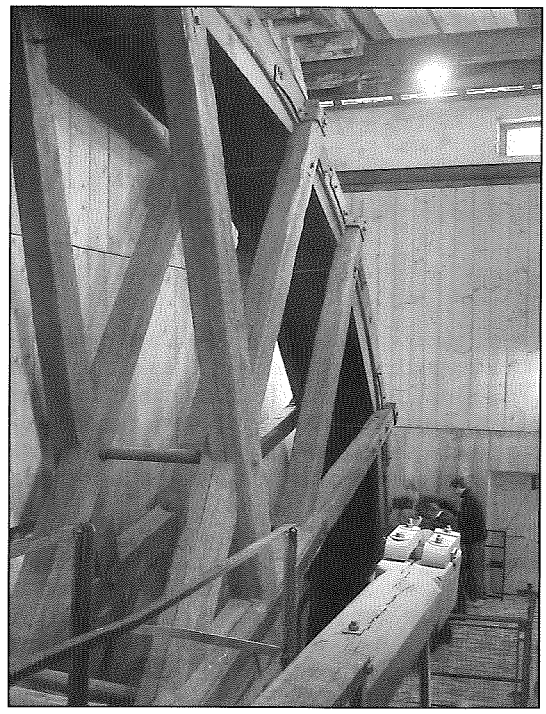


Fig. 2. Fig. 2. Wooden pumping water wheel, 13.6 metre diameter, Idrija, Slovenija (Peter Claughton).

We have also a rich heritage of features related to mining water power in the landscape. It is coincidence that these proceedings should be published on the 150th anniversary of the installation of the Great Laxey pumping wheel in the Isle of Man; the Lady Isabella Wheel (see front cover). It was probably the largest water wheel ever erected on a British mine and it still stands as a memorial to over 50 years of mining; shortly to be joined by another example, the Snaefell wheel, re-erected to demonstrate the use of water power in ore preparation. There are other surviving wheels scattered around our mining fields and wherever you go in the UK, Ireland, or further afield, you will find the structures and surviving earthworks for an infrastructure which powered mining over two thousand years. All those features require recording, interpreting and, where possible, protecting for future generations.

References

Ancel, B., Cauuet, B., and Cowburn, I. 2000 *The Dolaucothi Gold Mines.* Unpublished report for the National Trust in Wales.

Bartels, Christoph 1997 'Georg Winterschmitt's Water Pressure Engines in the Upper Hartz Mining District, 1747-1763', *Icon, Journal of the International Committee for the History of Technology*, 3, 24-43.

Bick, David E. 1976 *The Old Metal Mines of Mid-Wales, Part 1*, (Newent).
Bick, David. 1996 *Frongoch Lead & Zinc Mine*, (Keighley: NMRS, British Mining 30, 2nd edn.).

Bick, David E. and Davies, Phillip Wyn. 1994 *Lewis Morris and the Cardiganshire Mines*, (Aberystwyth).

Burnham, Barry C. 1997 'Roman Mining at Dolaucothi: the Implications of the 1991-3 Excavations near the Carreg Pumsaint', *Britannia*, XXVIII, 325-336.

Claughton, Peter. 1994 'Silver-Lead: Technological Choice in the Devon Mines', in Ford and Willies (eds.) *Mining Before* Powder, 54-59, (Matlock Bath: PDMHS Bulletin 12, 3).

Claughton, Peter 1996 'The Lumburn Leat - evidence for new pumping technology at Bere Ferrers in the 15th century', in Phillip Newman (ed.) *The Archaeology of Mining and Metallurgy in South-West Britain*, 35-40, (Matlock Bath: PDMHS, Mining History 13, 2).

Evans, T. 1862 'Description of water balance machines, used for winding coal, ironstone, &c., in South Wales', *Mining and Smelting Magazine*, 2, 30-33.