Visualising the Subterranean: Tunnels and Flows Beneath a Welsh Lead Mining Landscape

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Abstract This chapter discusses controversies that surrounded the construction of drainage tunnels beneath the lead mining landscape of Halkyn Mountain in North East Wales in the nineteenth and early twentieth centuries. Lead mining had a dramatic effect on the surficial and interior environments of the region, shaped social relations, and created distinct communities. As miners probed deeper to reach new veins, water levels rose in shafts and passages. Mine owners and syndicates embarked on drainage schemes. Mining and tunnelling sculpted the underlands of North East Wales, but provoked debates about power and privilege, the occupation and ownership of the subterranean, the nature of strata, and concerns over the flow, disruption and contamination of underground watercourses and local water supplies. Drawing on archival material, the chapter discusses the visualisation of Halkyn Mountain's hidden geographies, particularly through debates over the construction of the Milwr Tunnel. A socio-technical assemblage, the Milwr Tunnel was subject to a boosterism about "splendid" and "promising" discoveries of riches by unwatering abandoned mines and probing further underground to extract ore from new lodes. Engineers and miners were celebrated as pioneers and adventurers in revealing and shaping hidden worlds and unlocking mineral wealth, allowing, in the process, companies to map and control the subterranean. Above ground, there were local anxieties over the spread of mine shafts below and tunnels were criticised as monopoly schemes. Tunnels and underground channels raised questions over purpose, design and social and environmental impacts, and demands were placed on drainage companies to meet local social and economic obligations. The formations, structures, materialities and aesthetics of the underground, geological maps, and the flow of carboniferous limestone water, were essential to testimony presented at parliamentary hearings that visualised the shape and rupture of subterranean depths.

Keywords Lead mining · Drainage tunnels · Subsurface visualisation · Volumetric geographies · Halkyn Mountain · Flintshire · Wales

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1 Introduction

Recent approaches to territory, political geology, and elemental geographies have drawn attention to how thinking volumetrically about space and place enlivens our understanding of subterranean environments (e.g. Elden 2013; Bobbette and Donovan 2019; Hawkins 2020a). Volumetric perspectives have much to offer historical studies of mining, especially with respect to how the subsurface has been imagined, made legible, visible and knowable, and controlled, and how resource potential is anticipated, assessed and calculated (e.g. Endfield and van Lieshout 2018; Kama and Kuchler 2019; Kuchler 2017). As a contribution to scholarship on this and on the representations and politics of encounters with earthly materials and geological forces, the liveliness, restlessness and motion of rock and stone (e.g. Cohen 2015), and with the ways human activities are entangled with the earth's geological and temporal depths (cf. Clark 2017), this chapter discusses controversies that surrounded the construction of drainage tunnels to dewater the lead mines of North East Wales in the late nineteenth and early twentieth centuries. Venturing into the hidden geographies of Halkyn Mountain in the county of Flintshire, it explores how geological imaginaries and knowledge about the shape of the underground, the nature of strata and rock and theories about the flow and direction of water through Carboniferous limestone were essential to the visualisation of subterranean depths, the calculation of resource potential, and the social and environmental effects of tunnel construction. Halkyn Mountain was a busy working landscape on the surface as well as below. Local lives and economies were bound up with the formations, structures and materialities of the underground. Lead mining shaped the landscape and distinct communities grew around it. For Tilley and Cameron-Daum (2017: 5), landscape "has a material form with textures and surfaces, wet and dry places, scents and sounds, diurnal and seasonal rhythms, places and paths and cultural forms and built architecture that, through differential experience, is constitutive of different identities," and people and landscapes "are entangled in a network of material and social relations" (ibid.: 6). In the Halkyn Mountain area this entanglement involves the spaces, forms, substances, materials, pressures, forces and flows of what lies above and below ground.

Specifically, the chapter's focus sharpens on debates over the construction of the Milwr Tunnel, a socio-technical assemblage, which began in 1897 and was extended several times over the next sixty years. Tunnelling drained lucrative mines and allowed the discovery of new lodes, but concerns were expressed over the disruption and contamination of underground watercourses and local water supplies. Anxieties about the effects of the Milwr Tunnel on the water of a nearby holy well—a site of pilgrimage—were expressed by opponents to the project. The chapter draws on current research that is examining historical and archival material, including documents, engineering plans, maps and schemata, letters, newspaper reports, and the transcripts of parliamentary hearings to discuss how these debates centred on limestone, fissures and cracks, the nature of strata and mineral veins, the location of cross-courses and the direction of water flow. Geology and hydrology were essential to both the promotion and opposition of tunnel construction and for how Halkyn's

subsurface was imagined, represented and given form. The tunnel was subject to a boosterism about "splendid" and "promising" discoveries of riches by unwatering abandoned mines and probing further underground to extract ore from new lodes. Engineers and miners were celebrated as pioneers and adventurers in revealing and shaping hidden worlds and unlocking mineral wealth. This also involved expressions of an aesthetics of the underground (cf. Hawkins 2020b). Vertical imaginaries and the geo-logics and geo-optics of understanding, measuring, ordering and peering into subterranean depths sharpened ways of sensing and visualising Halkyn Mountain's interior geographies. Indeed, newspapers at the time reported on the parliamentary hearings as a battle between geological experts as they argued about the nature of the known, the unknown and the hidden.

2 The Lead Mining Landscape of Halkyn Mountain

Its topographical designation suggests a lofty peak, but Halkyn Mountain (Mynydd Helygain, in Welsh) is an upland plateau of mainly common land on a spine of Carboniferous limestone. Reaching a height of 293 m (961 ft.), it covers an area of 604 ha (1,492 acres) in Flintshire in North East Wales. Flintshire adjoins the English county of Cheshire and the Halkyn Mountain area is in many ways connected to and embedded economically and socially in the nearby Deeside conurbation. This region stretches across the Flintshire-Cheshire border and includes the city of Chester (Cheshire's county town) and several towns near the canalised length of the River Dee (Afon Dyfrdwy) which flows into the Dee Estuary (Aber Dyfrdwy). The Welsh–English borderlands shift, dissolve and merge here—as does much of the social and familial landscape—and this chapter arises from anthropological research (involving ethnographic and historical methods) that is part of a larger project concerned with the historical and contemporary nature of the region's rural-urban fringes, edgelands, in-between places, and post-industrial landscapes and waters. Along with lead mining, coal mining, brickmaking, copper smelting and steel production were also major industries in the nineteenth and twentieth centuries in Flintshire. Much of the region is filled with evidence of old lead mines, disused collieries, claypits and brickworks and this draws one's attention to the underground as much as the surficial, to reflect on what it means to live, work and deal with rock, clay, coal, lead, sand, water, and so on.

Looking east from Halkyn Mountain, farmland underlain by coal measures slopes down and—cut through by the A55 expressway (the main road across North Wales, from Chester to Holyhead)—reaches to the towns of Flint and Bagillt and the salt-marsh, mud and sands of the Dee Estuary, which Les Roberts describes as liminal "'empty' spaces in-between the coastlines of Wirral (in England) and Flintshire" (Roberts 2012: 104). An industrial landscape dominates the view of much of the Dee Estuary and Deeside. Major sites include the Connah's Quay Power Station, Dee Power Station, the Tata Steelworks, a paper mill and, a little further to the southeast, the Airbus aircraft wing factory at Broughton—while the Clwydian Range (Bryniau

Clwyd) of hills frames the view to the west. Its lowlier geography than the Clwydians and the higher, rugged mountains further west in the Ordovician landscape of Snowdonia belies Halkyn Mountain's historical importance as one of Britain's most valuable sites for the extraction of non-ferrous metals (lead and zinc ore) and quarried stone (mainly for different varieties of limestone and chert) over several centuries (Fig. 1).

The population around Halkyn Mountain is concentrated in four main villages—Halkyn (with around 2,800 people), Pentre Halkyn (approximately 1,100 people), Rhosesmor (around 560) and Rhes-y-Cae (some 350). A number of scattered houses, smallholdings and farms on the edges and slopes also make up the wider area. The town of Holywell lies near the plateau's northeastern edge. With a population of just under 10,000 Holywell is known for St. Winefride's Well, a site of pilgrimage renowned for having miraculous curative and healing properties. As this chapter relates, the well, which is in the care of St. Winefride's Church, a Roman Catholic parish church, was also a central actant in the debates concerned with tunnelling and in the narratives of Halkyn's hidden geographies

Halkyn Mountain is surrounded by farms but its common land has never been enclosed. The common land is owned largely by the Grosvenor Estate, which is under the proprietorship of the Duke of Westminster (also known as Earl Grosvenor) and whose seat is Eaton Hall, just over the border near Chester. Around 200 properties are registered as having ancient commoners' rights and some 1,500 sheep graze the rough, unploughed and unfenced pasture. Quarrying remains a major activity on Halkyn Mountain today, with three operations supplying a range of aggregates and

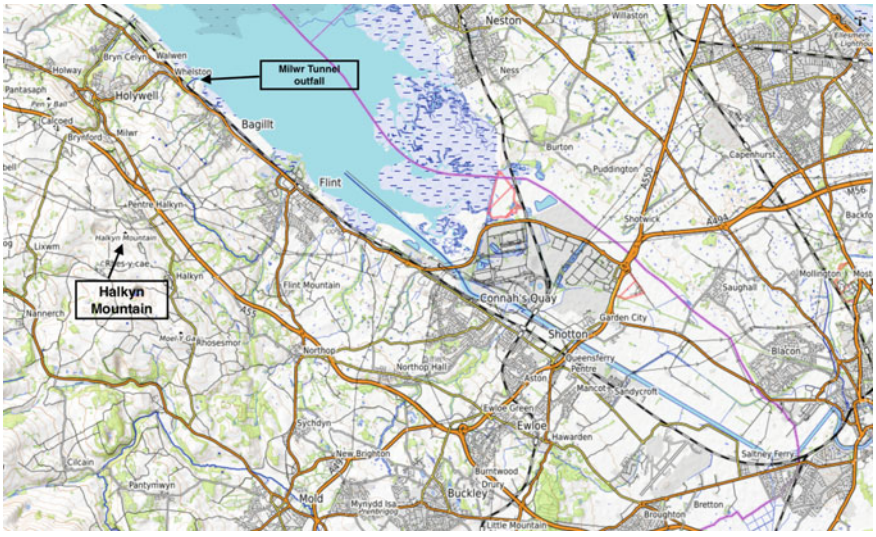

Fig. 1 Map of Flintshire showing Halkyn Mountain and the Milwr Tunnel outfall (author's annotations). Citation: Map courtesy of OpenTopoMap https://opentopomap.org/#map=12/53.2279/-3.0600 Map data: ©OpenStreetMap contributors, SRTM | map style: © OpenTopoMap (CC-BY-SA)

asphalt. The earliest mining of metal ores may have taken place in the Halkyn region during both the Bronze and Iron Ages. While precise archaeological evidence for this is lacking, extraction would have focused on shallow surface workings, with open cuts along the line of an ore vein. Mining for lead and silver in the area followed the Roman occupation of Britain, with operations supplying the frontier legionary garrison of Deva (the origin of Chester, established in the AD 70s on the banks of a navigable stretch of the River Dee). Extraction was also significant during the Middle Ages (Ebbs 2008; Frost and Jones 2004).

In the eighteenth and nineteenth centuries, the area became one of Britain's major lead mining zones (Frost and Jones 2004; Williams and Williams 2012). Landed families such as the Grosvenors began acquiring mines and mining licences in the early 1600s, and were given rights by the Crown in 1614, which meant they had effective control over much of the industry on Halkyn. A number of Flintshire and Cheshire families accrued wealth from lead mining, often by leasing mining rights from the Grosvenors. Many were also involved in smelting and other ancillary industries, such as silver production and silversmith work (Williams 2012; Williams and Williams 2012), which were established in nearby towns and villages, especially along the Flintshire shores of the Dee Estuary. The Quaker London Lead Mining Company also acquired mining rights in Flintshire in 1692 and was a major player in the region's lead and silver production for the next one hundred years, before abandoning its Welsh interests to concentrate on its mines in northwest England (Armour 1956). The Port of Chester, on the Welsh–English border, and small harbours along the Dee Estuary were key to the export of lead, and Chester shipping agents and merchants were prominent figures in the lead mining industry that developed not just around Halkyn Mountain, but in other parts of Flintshire and elsewhere in North East Wales. Lead products were transported by ships from estuarine ports to other parts of Britain, to Ireland and global markets, and the region prospered.

In the early eighteenth century, a lead mining boom brought incomers from Derbyshire, Cornwall and other parts of England. Skilled as lead miners in their home regions, they were often recruited by mining companies who required different kinds of extractive labour and subsurface knowledge than found in the communities around the nearby Welsh coal fields. They settled in the Halkyn district, some learned Welsh, and married into local families. English surnames such as Bagshaw, Nuttall, Redfern and Wagstaff became local names (Rhodes 1968; Ellis 1998) and remain part of today's social landscape. Many lead miners and their families lived in poor conditions on smallholdings and kept sheep and other livestock. This was a stark contrast to those who owned the mines and smelters, were engaged in trade, commerce and the silversmith industry, and who often built and lived in fine houses in rural Flintshire, Chester and other parts of Cheshire. Extraction, commerce and other industrial ventures contributed to the formation and shaping of the landscape and to the social and economic makeup of a region in which people and their livelihoods, and the fortunes of landowners, mining companies, entrepreneurs, and merchants, were linked together by a connection to Carboniferous strata.

The hidden geographies of Flintshire's underlands were revealed as miners dug into the earth, sunk shafts and carved out passages in a search for ore bodies. Mine

shafts were excavated vertically and horizontal passages—or levels—were driven off to give access to a mineral vein and to cross-courses (which are the intersections of east to west veins with north to south faults). When an ore body was discovered, it would be worked until the entire deposit was removed. With this burrowing, excavation and tunnelling, miners discovered interior chambers, caves, caverns, vertical pots, rift passages, watercourses and lakes that became part of a subsurface extractive zone transected by levels and other mine workings. In mapping the underground as extractive territory, shafts, lodes, veins and cross-courses were named—for example, Long Rake, Old Rake, Silver Rake, Deep Level, Pant-y-pydew, Pant-y-pwll-dwr, Chwarel Las, Powell's Lode, China Rake, Pant-y-ffrith and Caleb Bell. Knowledge of subsurface topography and strata was essential when miners navigated their way below ground. Many subsurface names also conjured images of geological riches deep in the earth and diagrammes and maps of veins and cross-courses were used to make the Halkyn underlands visible to potential investors. At the end of the nineteenth century, it was believed that an immense subterranean world of streams, rivers, lakes and caverns—and lodes—was still to be explored. Halkyn's interior was becoming known at a time when the scientific interest in caves was taking shape. This was also a time of growing popular interest in the elemental nature of the underworld, in descent narratives, and in adventurous subterranean travel (McCausland 2018). This was a different kind of frontier to imagine—there was no open space of air and light, but only darkness and walls of rock—requiring a vertical, rather than horizontal, perspective in making subsurface representation.

The last lead mine on Halkyn Mountain was closed in 1987. Around 250 major mining sites, with thousands of shafts, have been identified (Coyle 2010). Shafts, trial pit workings, and clusters of spoil heaps stretch along mineral veins and survive as evidence of lead mining's impact on the landscape and the subsurface. Many shafts have collapsed and their locations are indicated by grassy depressions and hollows, often surrounded by humps and mounds of spoil and mine waste (Fig. 2). Derelict land reclamation schemes have also altered the surface since the 1970s. Large numbers of deep shafts, some of which were also dug for ventilation and drainage, have been infilled and capped by stone and concrete, or have been covered with iron grates and fenced off. Apart from a few houses and mine offices—some of which have been converted to modern dwellings—most of the buildings and structures associated with past mining activities have disappeared, although ruined limekilns connected to quarrying and the production of hydraulic lime are now historic sites. Halkyn Mountain has designation as a landscape of historic interest—the area also includes prehistoric sites such as Moel y Gaer, an Iron Age hillfort overlooking Rhosesmor. As well as the shaft sites, Halkyn Mountain's surface is pock-marked by the foundation stones of buildings and boundary walls between mining concessions, horse whim circles and leats (artificial water channels), and is criss-crossed by miners' tracks, paths, and traces of old roads and wagonways along which horse-drawn carts carrying mined materials and lime would rattle. All this gives a tantalising glimpse of the activity that took place underground.

Fig. 2 Old lead mine workings on Halkyn Mountain. Photograph: Mark Nuttall

3 Watery Underground Spaces, Tunnels and the Geo-optics of Halkyn's Hidden Geographies

Lead mining was an encounter with limestone and damp, wet spaces. Flooding and drowning posed a significant risk. As Younger (2005) points out, mines not only produce minerals they "make water" and this was a considerable problem in the Flintshire mines. Moving and working within the watery underground required hydrogeological knowledge and demanded quick thinking about the best way to remove the water that flooded the spaces being hollowed. When miners probed deeper within Halkyn Mountain, water levels rose in shafts and passages, hindering production and bringing more hazards to an already dangerous occupation. Before steam pumps were first put to use after the invention of the Newcomen engine in 1712 (the London Lead Company first installed an engine house on Halkyn Mountain in 1729), underground water was taken to the surface in buckets or pumped out using horse-drawn machinery. As with lead mining elsewhere in Britain, such as Derbyshire (e.g. Endfield and van Lieshout 2018), Halkyn's water problem intensified after the 1750s once the more easily accessible veins had been worked. There were often violent, dangerous inrushes (cf. Younger ibid.), flooding passages, filling shafts and closing active workings. Adits were constructed, but mines flooded again when workings reached below them. The rising cost of coal to keep the steam pump engines in operation was prohibitive for some smaller mining operations, but the powerful flow of water also made effective steam pumping difficult. Attempting to solve the problem, mine owners and syndicates embarked on grander drainage schemes and tunnel construction. In 1774, the Holywell level was commenced by the proprietors of the Holway Mine near Holywell—some three metres above St. Winefride's Well and for

a length of 1500 m—and was used as a canal to barge ore from the mine (Appleton 1989). In 1818 Robert Grosvenor, the 2nd Earl Grosvenor, initiated the construction of the first major tunnel—known as the Halkyn Deep Tunnel—from Nant-y-Flint to drain water from the mines. It was abandoned in 1822, but work resumed in 1838 and the tunnel enabled the development of the Deep Level Lode (Appleton ibid.). Throughout the nineteenth century, small mining ventures were taken over by large companies and Flintshire was one of Britain's major lead mining areas, second only to the North Pennines orefield in England (Coyle ibid.; Frost and Jones ibid.). Yet the more easily accessible ore had been worked out and miners went deeper and below the water table. By the 1870s, some Halkyn mines had closed—water was certainly a problem, but many suffered from a fall in ore prices and competition from imported ore. Drainage tunnels were considered vital for rejuvenating the industry.

In 1875, an Act of Parliament empowered the Halkyn District Mines Drainage Company to take over and extend the Deep Level tunnel work that had been initiated by Robert Grosvenor. The company was also empowered to levy royalties from every occupier of a mine within the area it drained. Work commenced on the Halkyn Deep Level tunnel in 1876 (also known as the Halkyn Tunnel, Old Drainage or 1875 Tunnel). In August 1879, the company announced that the drainage scheme was successful—a strong current of water had been tapped and was flowing along the channel. By the late 1880s, the company reported to its shareholders that the tunnel had affected the drainage of a large tract of the country, led to "a wonderful discovery of lead ore", and had improved the condition of the lead trade, and so creating a far more hopeful feeling in the Halkyn district than had existed for many years. By 1901, the tunnel had reached the South Llyn-y-pandy Mine, nearly five miles (eight kilometres) from the portal.

A second tunnel—known as the Milwr Tunnel, or Sea-Level Tunnel—was begun in 1897 at sea level near Bagillt on the Dee Estuary. This was driven by the Holywell-Halkyn Mining and Tunnel Company, which was formed by a group of mining companies and empowered by an Act of 1896 to drain mines north of the Halkyn District Mines Drainage Company area (Frost and Jones ibid.). Geoscientific knowledge and data on the appraisal of subsurface resources supported promotional material about the region's promise. In 1896, the company published a prospectus for private circulation to potential investors, promoting Halkyn Mountain as containing "many marketable and valuable minerals" within "the richest metalliferous zone in Flintshire."[1] It gave details of reports from the company's engineers on the mines in the area and the estimated revenue and probable profits after completion of the tunnel "from the minerals proved in the cutting of the Tunnel in new lodes." It came with a fold-out map showing the planned route of the Milwr Tunnel, the mines and lodes it would drain and the ground it would open up, with a cross-cut of the tunnel stretching from sea level and the shafts running down into the Halkyn Mountain interior. The prospectus proclaimed that

[1] 'Milwr Tunnel Scheme. Prospectus of the Holywell-Halkyn Mining and Tunnel Company Limited (1896),' Flintshire Record Office, Document D/PG/303.

> Halkyn mountain contains an immense quantity of minerals, not merely lead ore and blende, but also cement, stone, chert (largely used in the Staffordshire Potteries), limestone (hydraulic and ordinary), superior fireclay. Owing to the present cost of high transport, the output of these minerals is limited, but with the cheaper transport afforded by the Tunnel, this output will greatly increase.[2]

In enticing investors, the company emphasised the advantages of location, transportation and harbours. The tunnel was necessary not only for draining water from the mines, but for placing the Halkyn district in immediate contact with the main line of the London and North-Western Railway and the River Dee, and through the latter with the River Mersey, the Manchester Ship Canal and various seaport towns.

These tunnels enabled the flow of water away from the mines and allowed access to the ore. Mining and tunnelling sculpted the underlands of North East Wales, and tunnel construction was subject to a boosterism—company reports to shareholders and the minutes of annual meetings are replete with claims of "splendid" and "promising" discoveries of riches to be made by unwatering abandoned mines and probing further into the uncharted underground to extract ore from vast lodes. For example, in March 1896, *The Flintshire Observer* reported on "substantial progress" made in preparations for the beginning of the Milwr Tunnel venture, announcing that it would "have undoubtedly great industrial bearing in this district." When progress with the tunnel was reported on during the second ordinary general meeting of the Holywell-Halkyn Mining and Tunnel Company, which was held in Chester in December 1897, it was remarked that the company had "materially increased its area" and that prospects were good for the development of a rich lead-bearing zone.[3] Immense quantities of lead were said by the company's executives and engineers to be buried in water and, in March 1898, further progress with the Milwr Tunnel was proclaimed as opening up "an exceedingly rich district." It was reported how "company after company have attempted to follow this great wealth to deeper workings, but each company succumbed to the water difficulty".[4] The Holywell-Halkyn Mining and Tunnel Company argued it was breaking down frontiers.

Above ground, however, there were many, including parish councillors, local business owners and farmers who were concerned about the spread of mine shafts, levels and tunnels. Debates raged about power and privilege, the occupation and ownership of the subterranean, and the nature of strata. Concerns were expressed that tunnelling not only diverted and disrupted the flow of underground watercourses, but that mining contaminated local water supplies. It was argued that the water draining from the Milwr Tunnel had the same source as that for St. Winefride's Well (also known as St. Winifred's Well and the variation in spelling is reflected in some of the documents, and in the words of key actors, referred to in this chapter). The water entering the well also feeds the Holywell Stream, which empties into the Dee Estuary near Greenfield, some two miles (three kms) away. A number of industries and businesses depended on the water, but it was also the source for Holywell's domestic

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[2] Ibid.

[3] https://papuraunewydd.llyfrgell.cymru/view/3753823/3753828/45/Milwr%20Tunnel.

[4] https://papuraunewydd.llyfrgell.cymru/view/3753913/3753921/102/Milwr%20Drainage.

water supply. Opposition to further tunnel construction focused on concerns and anxieties that the flow of water to the well—which was said to come from the south in the area of tunnel construction—would be cut. Arguments were put forward that local businesses and even pilgrims to the well should be compensated for the effects of any disruption to the underground stream that provided local water supplies. For example, in September 1896, the *South Wales Echo* had this to say:

> It is generally held that the principal source of supply to the well is a prolific subterranean stream which runs from Minera, near Wrexham, to Holywell, unwatering in its course a vast number of lead mines and the district generally through which it passes. The stream or "cross-course" in question is known as the "Caleb Bell" so named from the man who discovered it; and the fear is that the tunnel proposed to be constructed might tap this stream and so divert the principal source of supply to the well. The various local authorities have been asked by the promoters of the scheme for their sanction to it; but before doing so they have decided to get the best expert opinion obtainable on the matter. The diminution of the effluent would be a very serious matter not only for Holywell town and trade, but also for the manufacturers on the stream, who at present derive the motive power for their machinery from the overflow of the water.…"[5]

However, there were many geologists and mining engineers who disagreed. The source of the water feeding St. Winefride's Well was disputed by the advocates of the tunnel—and the geologists and hydrologists who were brought into support this position at parliamentary hearings in 1904 were cited that the water entered the well from the northwest, an area that would be unaffected by any tunnelling.

These controversies over the alteration of surface landscapes and the subsurface, and especially to the flow and contamination of water, dominated the parliamentary committee meetings and hearings over tunnel extension. In a seminal article, Martin Rudwick (1976) argues that geology did not develop fully as a science until it produced diagrammes and maps of strata and representations of interior geographies. The production of geological maps also became essential for understanding the location and nature of mineral resources. For example, Eric Nystrom (2014) explores how mining engineers in the late nineteenth and early twentieth centuries in America produced maps and models of mines that allowed the visualisation of subsurface geologies, tunnels and shafts. Similarly, for Halkyn Mountain, geologists and mining engineers conceptualised and gave order to the hidden geographies of the interior. Their maps and schemata, and other technical representations of strata and underground workings, provided further impetus to the exploration of these underlands by envisioning them as resource spaces of great potential. Through these geo-logics and geo-optics—techniques of classifying, ordering, seeing, imaging, mapping, making and knowing—spectacular representations of deep, dark places (that were sublime and beautiful) as regions of abundance intimated great returns to those who invested in subsurface zones of promise. The formation and shape of the underground also became essential in the parliamentary debates about the tunnels.

[5] "St. Winefride's Well: Feared tapping of the source," *South Wales Echo*, 2nd September 1896.

4 Locating the Watershed

Expansion of the Milwr Tunnel began in the early years of the twentieth century. Legislation to allow it was set out in the Milwr and District Mines Drainage Bill, which was debated in the House of Commons and before a House of Lords Committee in 1904. The Bill was promoted by the Duke of Westminster, the Earl of Derby, other landowners and mine owners, and those with interests in the tunnel company. The scheme consisted of a system of tunnels capable of carrying off 10,000,000 gallons of water per day; it was argued, however, that the tunnels already draining the mines ran through a formation of porous Carboniferous limestone from which the Holywell Stream drew its supply. Sir Thomas Esmonde, who was Member of Parliament for the Irish constituency of North Wexford at the time, moved the rejection of the Bill in support of local Flintshire interests. Holywell District Council, for example, was opposed to the tunnel, and many others in the area who depended on the Holywell Stream—including farmers, local business owners, mill owners, and riparian owners—worried about the environmental and social effects of interference with Holywell's water supply, as well as the impact on St. Winefride's Well. Concerns were expressed that the scheme was being promoted to enable a company to earn dividends and mine owners to make a profit at the risk of depriving the inhabitants of Holywell of their water supply and ruining the industries on which they depended for their livelihoods. The motion for the rejection of the Bill was seconded by Sir Charles McLaren (MP for Bosworth in Leicestershire, but also a Baronet of Bodnant in North Wales), who argued that if all the water "was to be sucked from the land" many Flintshire communities would be seriously threatened. The damage which would be done by the proposed underground tunnelling was irreparable, it was argued, and the town and industries would be ruined forever. Among the Bill's supporters was Samuel Moss, MP for Denbighshire Eastern in North Wales, who rejected the views of the opponents and argued that up to 1874 many mines in the neighbourhood of the well were worked at a level below it yet the flow of water remained unaffected.[6]

At the heart of discussion was the nature of limestone and the direction of subsurface water flow. McLaren argued that "the peculiarity of the water was that it did not flow on the surface of the ground, but went down fissures in the limestone strata, and at a certain level the water rose up again in great volumes. It was quite obvious that if tunnels were driven down below the existing stream the subterranean reserves would be drained to such an extent as to make the water flow not in its accustomed channel."[7] In written submission given on 7 July 1904, W. Fitzherbert Brockholes stated that

> The weight of evidence points to the probability, if not absolute certainty, that the volume of water from St. Winifred's Well will be greatly reduced even if the whole underground

[6] House of Commons Debate, Second Reading of the Milwr and District Drainage Bill, 9th May 1904, Hansard vol. 134, cc836.

[7] House of Commons Debate, Second Reading of the Milwr and District Drainage Bill, 9th May 1904, Hansard vol. 134, cc836.

> stream be diverted, and in the face of the evidence given to that effect I am at a loss to understand how Parliament could refuse in common equity the reasonable appeal for the provision of due compensation in the event of injury to the property of others being caused by the proposed drainage works.[8]

Supporters of the Bill pointed out that the area covered by the drainage scheme was acknowledged by numerous experts to be very rich in minerals. While Holywell District Council was opposed to the tunnel, Flint town council had unanimously adopted a resolution in favour of it on the grounds that it would be of advantage to the development of the area. The Bill's supporters also pointed out that other tunnels in the Halkyn area had not caused any harm to water flow, and disputed that Holywell derived its entire water supply from the underground stream diverted by the Milwr Tunnel. Robert Yerbergh, MP for Chester, said that while he could quite understand the feeling of those who held that St. Winefride's Well was a holy well sacred to the use of the sick and the lame, "who resorted to it for cure", those fears were "without justification," and that, given that many mines had closed because of flooding, the scheme put forward was essential to the development of the district.

The Bill proceeded through the House of Commons and the tunnel project was considered by a House of Lords Committee on the Halkyn drainage scheme. The parliamentary hearings were filled with discussion about the nature and shape of the subterranean. Limestone was described in incredible detail by geologists and debate raged as to the exact source of the watershed that supplied the well. The Caleb Bell cross-course and belief in the existence of a major subterranean channel became key elements in the narrative. The starting point for Caleb Bell is south of Rhes-y-Cae, and it terminates at the centre of Holywell High Street. It traverses the limestone beds of the district, and its course is indicated on the surface by numerous shafts. Experts argued that if tunnels were to be driven towards Caleb Bell they would interfere with the flow of water into the well. For example, Sir Aubrey Strahan from the Geological Survey (and who was later the Survey's director from 1914–1920) had authored a memoir on the geology of North East Wales which included his extensive survey of the Halkyn district (Strahan 1890), and he expressed his opinion that the tunnelling would pose a great risk of taking a large part of the water away from the well.

William Boyd Dawkins, another renowned geologist, was one of the key experts called in support of the opponents. He argued at the House of Commons hearings that a large underground reservoir lay below Halkyn Mountain, and that the subsurface geology was characterised by irregular cracks and fissures that influenced water flow. In testimony that was tinged by a sense of wonder, he described Halkyn's hidden underground geography as follows:

> The limestone is riddled naturally with joints; so much so that when it is exposed it takes up all the rainfall, less the evaporation. When the rain gets into the limestone it dissolves passages for itself and it forms clearly defined caverns, underground channels, which sometimes one can traverse for very considerable distances. There are sometimes great subterranean halls, and there are subterranean waterfalls and all the phenomena which you get, say in a hilly

[8] Opposition in the House of Commons Session 1904, Milwr and District Mines Drainage Bill, Document D/MT/1078, Flintshire Record Office.

> district were the water is tumbling on the surface of the ground from a high level to a low level.[9]

Giving testimony to the committee in March 1904, Dawkins said of the drainage scheme that

> In my opinion it must lower the level of the water in this area, which is, some of it at all events, on its way to St. Winifred's Spring;….it must deplete St. Winifred's Spring; and as to the further question – as to whether it would destroy St. Winifred's Spring altogether – that is a matter which is really a matter of experience; but by judging from other cases in which similar depletion has taken place (the Severn Tunnel) for example, I am of opinion that the effect of this long system of tunnels will be to destroy the head of water from which at all events a considerable portion of the water supply is derived, to such an extent that St. Winifred's Well may be absolutely dried up.[10]

James Mansergh, an English civil engineer also provided evidence in support of the Bill's opponents. He informed the committee that he had made a personal inspection of St. Winefride's Well, the local area, and the local industries that depended on the stream. He gave a description of Carboniferous limestone overlain by millstone grit and spoke about how the limestone was extremely permeable, with large fissures and caves, faults, and mineral lodes. The nature of limestone was central to his testimony, which described how water passed from limestone to millstone grit, and how exposed areas of dry limestone indicated the rapidity with which water finds its way into the rocks by way of fissures and faults. Mansergh talked about how it had been established that there was a fairly steep gradient in the subsoil water from south to north, towards St. Winefride's Well. He argued that "it is clear that a very considerable lowering of the subsoil water level will ensure, with the inevitable result of so flattening the water gradient summit to St. Winifred's Well that the discharge at that point will be materially reduced and may be altogether stopped."[11]

Nathanial M. Griffith, a mining engineer from Wrexham, argued that the Caleb Bell cross-course was key to an understanding of whether or not the tunnel would affect the water supply to St. Winefride's Well and the Holywell Stream. Griffith produced a drawing showing the position of the Milwr Tunnel and the five proposed tunnels—and he showed on geological maps that it was crossed by a large fault, which threw the strata down to the south, with the beds to the east of Caleb Bell dipping towards it for some distance north. He argued that this would bring underground water to Caleb Bell at the point of its junction with the fault, which offered greater flow for the passage of water. Griffiths argued that if Caleb Bell was tapped at a level lower than the well its feed would suffer.

Arthur Caradoc Williams, chief assistant to Henry Enfield Taylor, a mining engineer from Hawarden, Flintshire and who practised in Chester, spoke about an inspection he had made of the district and of the Caleb Bell vein, the depths of shafts and the

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[9] Opposition in the House of Commons Session 1904, Milwr and District Mines Drainage Bill, Document D/MT/1078, Flintshire Record Office.

[10] Opposition in the House of Commons Session 1904, Milwr and District Mines Drainage Bill, Document D/MT/1078, Flintshire Record Office.

[11] Opposition in the House of Commons Session 1904, Milwr and District Mines Drainage Bill, Document D/MT/1078, Flintshire Record Office, pp. 2–3.

water level. He showed the committee detailed geological maps with the locations of east, west, north and south running veins. In particular, he pointed to how Caleb Bell, for nearly the whole of its length, traversed the limestone beds of the district and explained how its course was indicated on the surface by numerous shafts. He described how limestone strata are traversed and cut up by cracks, joints, veins and faults, and that all these form channels for the water falling on the surface and carry it away underground. The parliamentary committees heard that this was a dry landscape—how rain finds its way quickly into the ground, little runs off, and how Caleb Bell extended across the limestone belt and provided a necessary main channel along which the water could find its way.

Material submitted for consideration by the committee not only included geological maps and models, but also statistics on the yield of water at the well. For example, the committee heard about a report produced in 1895 by Major-General Charles Scrope Hutchison, who was an inspector for the government's Board of Trade, which concluded that the average yield of St. Winefride's Well was reduced by nearly 50% after the Halkyn Mines Drainage Tunnel was driven and brought into use in 1882. At the time, however, and despite Strahan's detailed survey and the evidence presented, other geologists argued that the exact nature and extent of Caleb Bell was not known, and the tunnel proponents drew on this when claiming the water would not be affected. The evidence in support of the proponents was put forward to argue that the water flowed from the west or northwest and not from the south. For example, Honoratus Lloyd put forward the case to the House of Commons committee that the water came from the west or possibly the south-west. He referred to a diagramme of lodes, veins and faults and argued that no one could say where the water flowed and that there was no known or defined underground channel. The House of Lords committee heard from leading geologists William Whitaker and Richard Hill Tiddeman that the well was supplied by underground water that flowed from the west. Tiddeman said that he thought there to be an impervious barrier somewhere to the south of the well which would make any water flowing from the south to turn north somewhere to the west of it, and which would prevent it from reaching the shrine.

Despite the opposition, the Bill passed into law. The committees were not convinced of the arguments put forward that the water feeding the well came from the south. Notable supporters in the House of Lords included those landowners with lead mining interests in Flintshire, such as the Duke of Westminster and the hearings, and the debates focused on the Halkyn underlands as spaces of possibility. At the Holywell-Halkyn Mining and Tunnel Company Annual Meeting in May 1905, consulting engineer Captain Matthew Francis said that

> The company would not only have the safest, but the straightest and most capacious, and in its drainage effects the most exhaustive main drainage tunnel that to my knowledge has even been made to unlock the mineral wealth of any district and, it should prove a source of profit to the company as well as a boon to the metalliferous miner for many years to come.

5 Further Tunnel Expansion and St. Winefride's Well Runs Dry

Plans for further expansion of the Milwr Tunnel were put forward almost a decade later. In 1913, the Halkyn District Mines Drainage Bill was presented in the House of Commons to empower the Halkyn District Mines Drainage Company through an Act of Parliament that would allow it to extend the tunnel into their drainage area, as well as several other tunnels under Halkyn Mountain. A powerful economic argument was put forward by the tunnel company and by mine owners. In particular, Flint County Council was supportive of the Bill and argued that drainage of the mines would restore the prosperity of the lead mining industry, increase employment in the area, and benefit other trades and industries. The council argued that unless the Bill was passed and the tunnel constructed the mining industry in the district would languish and gradually come to an end. The flow of water into St. Winefride's Well was once more central to the parliamentary enquiry that debated the Bill that preceded the Act and maps and models were used as necessary evidence.[12]

A petition against the Bill was brought forward by Lady Anna Maria Mostyn and John McKean. Lady Mostyn was the widow of Sir Pyers Mostyn, who had died in 1912, and who had opposed the 1904 Bill. McKean, an Irish nationalist politician and MP for South Monaghan from 1902 to 1918, was a frequent visitor to Holywell and desired to represent the interests of visitors and pilgrims to St. Winefride's Well. McKean had also opposed the 1904 Bill and had argued then that the flow of water to the well had been diminished because of the Milwr Tunnel. The petition outlined how the Mostyn family was the owner in fee of lands, mills and other buildings on the Holywell Stream, with a legal right to use the water which was indispensable for those lands, industries and businesses. The petition stated

> The Holywell Stream flows from St. Winifred's Well into the Dee near Greenfield, a distance of about two miles. It derives its water almost entirely from the Well and the Well is fed by a stream flowing through what experts believe to be a known and defined subterranean channel which they can trace for a distance of several miles inland across and beyond the district in which the works proposed by the Bill and the works which can, under the Bill, be connected with them are situate. But whether the Well is fed by one or more subterranean streams and whether their course can be certainly defined or not, the injury which could be caused to your first-named Petitioner by the interruption of the flow of the stream and the abstraction of its water, would be equally great. The Well is, moreover, the chief and the only wholesome and unfailing source of supply of water for domestic purposes in the town of Holywell.[13]

Mostyn and McKean argued that large numbers of pilgrims and others visited the shrine every year and the use of its waters for bathing was an important source of revenue for Holywell. The petition also stated that

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[12] D/MT/1084 min of Evidence taken before the Select Committee of the House of Commons on the Halkyn District Mines Drainage Bill, July 1913.

[13] D/MT/1084 min of Evidence taken before the Select Committee of the House of Commons on the Halkyn District Mines Drainage Bill, July 1913.

> As far back as any records exist the flow of water from St. Winifred's Well was remarkably constant and never fell below six million gallons per diem. But about 25 years ago in consequence mainly in not wholly (as your Petitioner Dame Anna Maria Mostyn believes) of the construction of the Halkyn Tunnel, a deep level drainage tunnel similar and adjacent to the tunnels proposed by the Bill, the flow of water in St. Winifred's spring suddenly fell to one-half of its former volume and at that point has since remained.[14]

In the evidence she presented to the 1913 House of Commons committee, Lady Mostyn argued that St. Winefride's Well was fed from a distant and proved source, which the Halkyn Company tapped to a considerable extent in 1882 in their first operations, and that the deeper level of many large tunnels, precisely in the same direction, would withdraw a further supply of water from the well. She spoke eloquently about Carboniferous limestone and that after the heaviest storms the well remained clear for two-and-a-half days before discolouring. Lady Mostyn referred to local tradition in Flintshire, and particularly around Holywell, that held that a great river flowed underground—if a network of tunnels were completed and linked together, she argued, it would disrupt the flow of water and seriously affect the well. McKean also argued that the length of time it took for the water in the well to become discoloured following heavy rainfall showed that the water originated from a considerable distance to the south. However, William Whitaker appeared as a witness to discuss the nature of strata. He said that it was difficult to determine where the watershed of the well was located, but felt that a large outcrop of limestone to the north-west was a likely place, and that the well would collect water from a variety of sources, not just from water flowing from the south and south-west.[15] Other geological experts and mining engineers produced maps to explain that the water came from the north and west—evidence being presented that south of the well there were numerous faults in the shape of lodes, which dipped to the south, which meant that the geological structure precluded the theory that water from the south flowed to the well.[16]

Captain Matthew Francis was also examined as a witness. He told the committee that he had lived in the area all his life, had more than 45 years experience of mining in the region and had also tunnelled for many miles. He argued that the geological structure precluded the theory that water from the south—that is, from the district that would be drained by the tunnel extensions—went to the well. Instead, pointing to a map, he said that it was his opinion that the watershed feeding the well was situated to the west-north-west and south-west of Holywell. The committee heard evidence from Francis and others that a number of mines south of Holywell had been drained—in some cases below sea level—without affecting the well. The argument that no sudden diminution in the flow of water to the well occurred when the Halkyn Tunnel that was first driven was key to the expert witness statements. At the same time, Francis and other experts argued that the existing Milwr Tunnel was nearer the

[14] D/MT/1084 min of Evidence taken before the Select Committee of the House of Commons on the Halkyn District Mines Drainage Bill, July 1913.

[15] D/MT/1084 min of Evidence taken before the Select Committee of the House of Commons on the Halkyn District Mines Drainage Bill, July 1913.

[16] D/MT/1084, Minutes of Evidence taken before the Select Committee of the House of Commons (Group E) on the Halkyn District Mines Drainage Bill, Tuesday July 1st, 1913, p. 5.

well—about 199 feet below the level of the well at a point 1 ¾ miles (about 2.8 kms) distant—than any part of the proposed tunnel network would be and that it had not affected the flow of water.

Geologist and mining engineer Frederick Henry Hatch was also called as expert witness and declared that he felt there was very little probability of damage being done to the well. Cross-examined by several committee members about the origins of water for the well, Hatch pointed to the geological map of the area and argued that the supply was from the limestone areas to the west. He said the limestone overlay Silurian shales on the west and dipped under the coal measures on the eastern side of the Halkyn area. Indicating the area of limestone and the location of cross-courses on the map, Hatch said that

> The blue is the area of carboniferous limestone from which the water of the district is supplied. In my opinion, the water that comes from the well is supplied from this area, which lies to the west and north-west….The dip of the limestone is from the west to the east, and the natural flow of the water would be along the dip…..That is well known to every geologist, and of course is shown on the Geological Survey map.[17]

He explained how a limestone formation has fissures in it, but that the fissures in the Halkyn district have been filled by the deposit of mineral matter and sealed, thereby producing the veins and the cross-courses:

> in this area, there are a great number of these cross-courses which run north to south and veins which run from east to west which act as barriers to the flow of water and the result of it is to divide this particular area of limestone up into practically water-tight compartments, and that is borne out by the irregular level at which the water stands in these shafts.[18]

For Hatch, cross-courses acted as natural dams, ponding the water, not carrying it, and he did not see the tunnel as bringing any new source of danger. Supporters of the Bill argued that there was no evidence that St. Winefride's Well was fed by a defined, hidden subterranean channel which could be traced for a distance of several miles. Geologists were also called as expert witnesses to present this view. They also argued that very extensive pumping of underground water had been going on very much nearer the well and which had not affected it. The argument that mills were dependent on the stream was also disputed and that local industry and businesses had another significant source of water supply that was independent of the well and which could not be affected by the tunnel and drainage works. Figures from gauging studies were presented to show that the water in St. Winefride's Well was not constant and varied considerably with rainfall and that no relation between pumping from the mines and the rise and fall in the well could be proved. Evidence was also heard that draining mines was a matter of safety for the miners, would prevent drowning, and provide air for those underground. Also, more men could be employed if mines were

[17] D/MT/1084, Minutes of Evidence taken before the Select Committee of the House of Commons (Group E) on the Halkyn District Mines Drainage Bill, Wednesday July 2nd 1913, p.30

[18] D/MT/1084, Minutes of Evidence taken before the Select Committee of the House of Commons (Group E) on the Halkyn District Mines Drainage Bill, Wednesday July 2nd 1913, p. 30

not waterlogged. And so, the proponents and supporters of the Bill put forward a persuasive case that St. Winefride's Well would not be affected and that the Holywell Stream would be able to supply the same amount of water to the mills. The Bill passed into law and the Halkyn District Mines Drainage Company was empowered to extend the Milwr Tunnel and construction work began.

In May 1916, however, there was a notable reduction in the flow of water to St. Winefride's Well. An investigation was commissioned by the Mostyn Estate and the report, completed by mining engineers W.J. Davies and Cyril Davies the following September, concluded that it was down from 6,000,000 gallons per day to as low as 86,000 gallons a day and to a high of 900,000 gallons a day. Cyril Davies had inspected the Milwr Tunnel extensions on Friday 1 September and found that a number of fissures had been struck within the area from which the evidence presented in 1904 and 1913 contended the supply to the well derived. Concerned over the impacts on the town's water supply and the industries in the area, Holywell Urban Council also requested inspection reports and gaugings of the flow of water to the well. These reports concluded that the quantity of water issuing from the fissures crossed in the Milwr Tunnel extensions was equal to the decreases registered at the well between April and August 1916, and accounted for the diversion of the source of supply.[19] By January 1917, the well had dried up—although flow eventually resumed it was not enough to provide water for local industry and so a level was driven from an abandoned mine shaft—the Roskell Shaft—to replenish the flow into the Holywell Stream.

6 Conclusions

From the late nineteenth century, the construction of tunnels in the Flintshire lead mining areas became central to the realisation of ideas about promising discoveries in an expanding resource zone. As socio-technical assemblages, the need for tunnels under Halkyn Mountain was argued as essential for the opening up of a subterranean frontier—and there are parallels in how oil and gas pipelines are promoted today around the world (e.g. see Nuttall 2014 for a discussion of how this is so in north-west Canada). Miners and engineers were celebrated as pioneers and adventurers as their digging, extraction and tunnelling revealed hidden worlds and unlocked the mineral and metal wealth of North East Wales. However, as miners probed deeper to reach new veins, water levels rose in shafts and passages. Drainage schemes were attempted to ease the problem and dewater the mines. For mine owners and their investors, construction of the Milwr Tunnel was considered a triumph of engineering interventions and of human progress over nature. This allowed mining and tunnel

[19] These reports along with a series of letters and details of water gauges are archived at the Flintshire Record Office, Document D/MT/1085.

companies to map, mark out and stake claims to rich lodes, and control the subterranean. However, tunnels provoked debates about power and privilege, the occupation and ownership of the subterranean through the placing of infrastructure, and concerns over the flow, disruption and contamination of underground watercourses and local water supplies. Yet, as the transcripts of the parliamentary committees and hearings show, the lives and experiences of people who ventured in and out of the depths, who engaged with the underground, worked with rock and extracted the ore, were not taken into consideration. The words of the miners, as well as local people who lived with water, are not inscribed in the official record. It was geologists and mining engineers who were considered the experts—and this chapter's narrative shows that it was their knowledge and theories about the formations, structures, materialities and aesthetics of the underground, along with geological maps, inventories of rock, stone, metals and minerals, and the flow of Carboniferous limestone water, that became to the testimony at the 1904 and 1913 parliamentary committee hearings. Geoscientific knowledge was essential for describing and envisioning what was known about the underground and the hidden (cf. Kuchler 2019). Just as imperial expeditions across oceans and terrestrial surfaces used images "as key techniques in the processes of investigating, ordering, explaining, and possessing – or attempting to possess – nature" (Bleichmar 2012: 7), maps and models of mines, the depiction of strata, and hydrogeological knowledge were essential for the visualisation, possession and engineering of Halkyn's interior spaces (see also, Nystrom 2014).

The Milwr Tunnel expanded. Throughout the 1930s, Halkyn District United Mines, which was formed in 1928, continued driving the tunnel and with mining ore from the veins accessible from it. Some 650 men were employed. In 1938, however, the low price of lead forced the laying-off of most of the workforce. No mining was carried out during the Second World War, but quantities of TNT explosive were stored underground on Halkyn Mountain for the Ministry of Supply in specially constructed stores. In 1948, work on driving the Milwr Tunnel was restarted. This continued until 1957, when the tunnel reached the Cathole Vein, near the Mold-Ruthin road, over ten miles (sixteen kms) from the portal. It had been intended to drive the tunnel into the mines to the south, in the Maeshafn-Llanarmon area of Denbighshire, but this plan was abandoned and mineral leases in this area were given up in 1960. Lead ore was mined at intervals up to 1977, but most extractive industry on Halkyn was focused on quarrying high-grade limestone for Pilkingtons, a glass manufacturer. The Milwr Tunnel was maintained because it had become an important water supply for the Courtaulds rayon mills at Holywell and Flint (the last mill closed in 1989). The last lead mine on Halkyn Mountain may have closed in 1987, but each day 23,000,000 gallons of water flow into the Dee Estuary from the Milwr Tunnel outfall, known locally as "The Holy," near Bagillt (Fig. 3). This flow is closely monitored and much of it is used by industry on Deeside.

Fig. 3 The Milwr Tunnel outfall into the Dee Estuary, near Bagillt, Flintshire. Photograph: Mark Nuttall

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