

Hydrogeology of Wales: Carboniferous aquifers - the Coal Measures facies

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This page is part of a category of pages that provides an updated review of the occurrence of groundwater throughout Wales.

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The study of groundwater occurrence in the Coal Measures facies of the south and north Wales coalfields has mainly been related to problems of mine drainage and possible inrushes of groundwater into workings from fracture zones and flooded old workings. However, Carboniferous strata also form significant aquifers in both south and north Wales. The hydrogeology of the South Wales Coal Measures Group was first described by [Ineson \(1967\)](#) who had the benefit of access to a large number of then active coal mines and the National Coal Board records research departments, now superseded by the Coal Authority. The hydrogeology of the coalfield was later revisited by [Rae \(1978 a or b?\)](#).

The general hydrogeological character of the Coal Measures Facies consists of low permeability hydrogeological units composed of carbonaceous mudstones and sandstones with subordinate siltstones and coal seams. The Pennant Sandstone Formation is dominated by sandstone whilst the Lower and Middle Coal Measure formations are dominated by mudstone. Moreover the Pennant Sandstone Formation is generally thick, massive, feldspathic and micaceous and forms the relatively high ground at the centre of the South Wales Coalfield. The permeabilities of the sand horizons are generally less than 1 m d^{-1} , typical of tight sandstone layers; [Ineson \(1967\)](#) provided transmissivity values for sandstone horizons ranging from 10^{-1} to $20 \text{ m}^2 \text{ d}^{-1}$. Fracture permeability enhances the transmissive properties of these rocks although secondary deposition of silica may inhibit matrix permeability. Folding and faulting has produced some secondary fracture permeability, and mining activity tends to enhance fracture permeability in the overburden. At outcrop, borehole yields up to 8 l s^{-1} are feasible, but the permeability of the sandstone horizons depends on the distribution and intensity of fractures within them.

North Wales Coal Measures

The Coal Measures crop out along the Dee Estuary, from the Point of Ayr, south eastwards through Flint and south towards Wrexham and Oswestry. The strata are faulted and broken but there is a small regional dip towards and beneath the Cheshire Basin to the east. The productive Pennine Coal Measures Group typically comprise up to 600 m of pyritic shales and mudstones with subordinate sandstone horizons, thin ironstone bands and coal seams. The sandstone horizons tend to become more significant towards the Wrexham area. The unproductive Warwickshire Group overlies the coaliferous strata:

Halesowen Formation	sandstone and subordinate marl	900 m
	calcareous sandstone	160 m
Etruria Formation	marl	330 m
Pennine Coal Measures Group	includes sandstone horizons	600 m

Groundwater transport and storage is largely limited to available fractures, although there is some

storage available in the sandstone horizons and in former mine workings. Yields up to 5 l s^{-1} have been attained in boreholes, exceptionally 15 l s^{-1} at a borehole near Mold [SJ 24186348]. All the collieries required to be dewatered during their working life, usually through shaft sump pumping, and occasionally by adit drainage to a valley side. Shaft discharges were generally of between 5 and 20 l s^{-1} , some shafts with pumping rates that fluctuated seasonally. However, both vertical and horizontal conductivity are poor and initial pumping rates may not always be sustainable. In places, groundwater is confined by the till, as a borehole at Bryn-y-Cwm in Flint [SJ 23687159] testified, and which overflowed for a while after completion at 0.1 l s^{-1} having penetrated 40 m of till over Coal Measures sandstone.

Water quality, particularly in the productive coal measures facies is poor due to the availability of soluble hydrous products of pyrite within the worked coal seams, which had been oxygenated whilst dewatering took place and later flooded on abandonment of the collieries. Quality is better in the Warwickshire Group, with total dissolved solids concentrations up to 2000 mg l^{-1} , and some spring sources, drawing on shallow circulation perched groundwater in individual sandstone horizons, yield relatively weakly mineralised but generally small volume discharges.

South Wales Coalfield



The main shaft and buildings at Tower Colliery prior to closure in 2008. The dark green area is reclaimed opencast land and contrasts with the yellow-green natural vegetation in the foreground. P802424.

The South Wales Coalfield is an exposed synclinal basin some 87 km long by 30 km wide with an overall area of some 2200 km^2 . Coal production in south Wales peaked at the start of World War One, but declined steadily after the general Strike of 1926 ([Brabham, 2004](#)). Wholesale closure of the coal mines took place subsequent to the political decision to reduce dependency on the UK coal mining industry in the late 1980s and early 1990s. The last working pit, Tower Colliery [SN 939 054], near Hirwaun, was closed in January 2008 (**Plate P802424**) while two pits have been reopened in the Vale of Neath. As with many of the South Wales collieries, Tower was part of a large interconnected mine complex, with connections between shafts up to ten miles apart being common.

Mine-water rebound is now well advanced over much of the coalfield and there are no ongoing deep mine dewatering schemes. Steady state conditions have occurred in some areas where piezometric levels are now controlled by gravity discharges from the mines. Some of these require treatment (see [Management and regulation of groundwater](#)) – there were eleven mine water treatment schemes operating in 2009 at abandoned flooded coal mines in south Wales. Morlais [SN 572 023] is of note since the high flow of iron rich mine water required construction of (at the time) the largest constructed wetland in Europe by the Coal Authority (see www.coal.gov.uk).

Erosion and down-cutting by major rivers has created incised valleys along major fault zones. These valleys are significant areas of groundwater/surface water interaction. The Vale of Neath divides the coalfield into a lower lying area to the west, over the anthracite field, although rising to the north and the Black Mountains, and a higher area to the east, over the bituminous coals, where

topographical divides rise to over 600 m elevation.

The South Wales Coal Measures Group thickens west of the River Neath, there being about 600 m present in the Ferndale-Taff Valley whereas there is 1500 m in the Gower at Gorseinon. The sandstones tend to form the higher ground and form the steep valley sides of many of the incised rivers. The South Wales Coal Measures Group are partly concealed by glacial till and outwash deposits which range up to 100 m in thickness in the Tawe Valley, but are generally less than 30 m thick. They are partly concealed by estuarine coastal flats in the south which are up to 30 m thick.

Within the central and eastern parts of the coalfield the South Wales Lower Coal Measures Formation ranges between 120 m and 210 m in thickness. The South Wales Middle Coal Measures Formation ranges between 210 m and 260 m in thickness. Both formations comprise fluviodeltaic sediments that consist of coarsening-upwards cycles of mudstones, siltstones and sandstones with siltstones containing ironstone layers, siderite and pyrite. Each cycle is capped by a coal seam underlain by seatearth:

Seatearth - including clay and coarse sandstone with ironstone bands

Arenaceous - quartzitic sandstones ranging upwards to coarse pebble layers

Striped beds - comprising quartzitic siltstones and mudstones

Argillaceous - ranging from clays to silty mudstones

The Warwickshire Group consists of 670 m of strata, mainly of the massive Pennant Sandstone Formation. The Pennant Sandstone Formation comprises thick, cross-bedded units with some coal.



St Mary's Well at Penrhys - a spring issuing from Pennant Sandstone on the side of the Rhondda Fach above Fernadale. P802425.

A study of the Pennant Sandstone Formation at Merthyr Tydfil indicates that the intergranular permeability of these well-cemented sandstones is small and that transport and storage is largely limited to fractures. Undermining may enhance tensional fracturing and increase the overall hydraulic conductivity of the sandstones. The majority of infiltrating rainwater penetrating the sequence is diverted by shale and mudstone horizons to emerge as hillside springs and discharge to surface waters as base flow (**Plate P802425**).

Throughout the South Wales Coal Measures Group there appears to be little significant vertical flow along faults, although flow from the shallower sandstones has managed to penetrate some of the deeper mines. The coal mines of south Wales were some of the wettest in England and Wales requiring eight tonnes of water to be pumped on average for every tonne of coal recovered. However, [Rae \(1978 a or b?\)](#) reported that this figure may be misleading as 30 per cent of the south Wales mines pumped at $<4 \text{ l s}^{-1}$, a further 40 per cent $<20 \text{ l s}^{-1}$ and only 15 per cent were very wet mines which required to pump at discharges $>50 \text{ l s}^{-1}$.

Severe problems were occasionally encountered with water inrushes in collieries situated towards the northern and eastern margins of the coalfield. Inrushes could occur through the roof or the floor of workings and were worst in collieries situated some considerable distance from outcrop. Inrush risk focused on an area that was sufficiently distant from outcrop for mine dewatering to attain sufficient pressure differential to create a burst, but not so deep that fracture dilation was reduced and groundwater transport inhibited. The area east of a line between Ebbw Vale and Caerphilly was the critical area. Initial flows were typically between 50 and 80 l s^{-1} , exceptionally 200 l s^{-1} and they generally declined with time (see detailed listing in [Ineson, 1967](#), pp.6-8). A few inrushes stabilised with significant yields up to 30 l s^{-1} , reflecting greater fracture storage than those systems which quickly dropped off in yield. In the eastern part of the coalfield the thickness below the lowest worked seams and underlying sandstones in the South Wales Lower Coal Measures Formation and the Marros Group can be as little as 10 m, and floor bursts were not uncommon; in some cases the source may have been from the Pembroke Limestone Group wherever faulting was present to provide a suitable conduit.

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