

Hydrogeology of Wales: Precambrian and Cambrian aquifers - groundwater occurrence in the Precambrian and Monian Supergroup

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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.

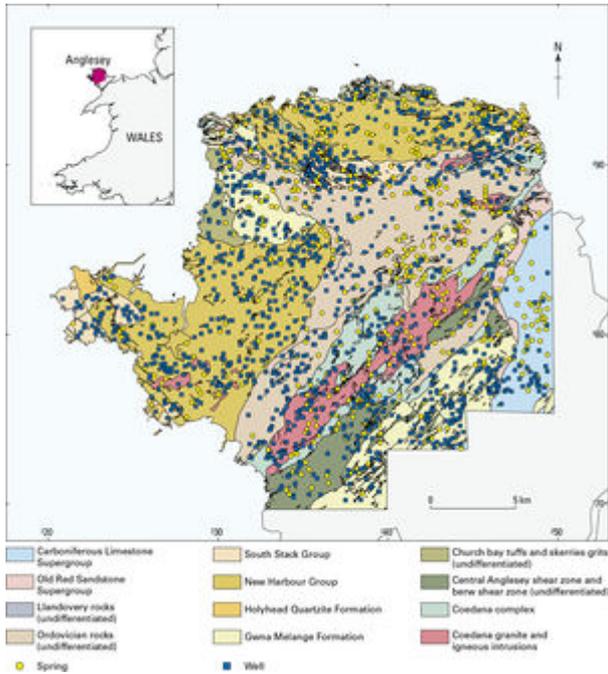
Author(s): N S Robins and J Davies, British Geological Survey

Contributor(s): D A Jones, Natural Resources Wales and G Farr, British Geological Survey

Awareness of the groundwater potential in the Precambrian was first documented by [Greenly \(1919\)](#) in his treatise on the geology of Anglesey. He identified the importance of contacts between different metamorphic lithologies and between the metamorphic rocks and the Silurian and Carboniferous sequences, especially low angle contacts and the contacts between dykes and country rock. Remarkably, Greenly also recognised the vulnerability of weathered fracture systems to surface pollutants.

Groundwater circulation in the crystalline basement rocks is shallow and restricted to short flow paths on a local catchment scale within selected fractures. Partial superficial cover of till may contain perched water but may also inhibit rainfall recharge to bedrock. There is little storage available in the basement and discharges to surface may be intermittent and quick to react to rainfall events. The hydraulic flow patterns are complex and application of conventional hydraulic theory is restricted. Even the effective transmissivity based on regional water-balance considerations may not represent a mean of transmissivity values determined in the regional flow regime ([Shapiro, 1993](#)). Nevertheless, crystalline rocks do contain some groundwater, and it is a resource which is often under-used in Britain whereas it has been widely developed in areas such as Scandinavia ([Banks and Robins, 2002](#)).

Yields from springs, wells and boreholes are general small and not easy to evaluate in terms of aquifer properties. Statistical analysis of hydraulic data provides the most appropriate means of comparing the performance of different lithostratigraphical zones in a given area. In general this is not carried out in the UK because of insufficient data, but a dataset collected for the Monian Supergroup in Anglesey for apparently unrelated reasons in the 1970s has allowed such an analysis ([Robins and McKenzie, 2005](#)). Data on the location, source type and geology of 1775 sources have enabled an analysis of the productivity of the respective lithostratigraphical zones.



Location of springs and wells in north-western Anglesey (after Robins and McKenzie, 2005). P859260.

Spring discharges from the basement rocks in north-west Anglesey and Holyhead Island are, for the most part, small, typically less than 2 l s^{-1} . An exceptional series of springs supplied the Twr Waterworks on Holy Island [SH 226 824] where three springs in close proximity discharge to surface with an average total yield of 5.5 l s^{-1} . Although few water boreholes have been drilled, the 10 m deep railway borehole near Holyhead Station [SH 261 812] yielded 1.5 l s^{-1} for 12 hours per day.

Shallow wells in till offer prospects of perched water in gritty, moderately permeable horizons. Not all of the wells penetrate bedrock. Springs are common at the base of the unconsolidated till over bedrock. Blown sand deposits are well drained and unsaturated, and the alluvium is generally fine grained and weakly permeable.

The well and spring dataset comprises three pieces of information: grid reference, well or spring, and geological observations for most data points. The geological observations identify some wells in till only, wells and springs at the junction between till and bedrock, and bedrock springs and wells in close proximity to a dyke or a stratigraphical or lithological contact.

The location of the springs and wells over the solid geology is shown in **Figure P859260**. When contrasting the intensity of field collected data for the area with that held in the BGS Wellmaster database (**Figure P859260**) a number of other features become apparent. The first is that the distribution of wells and springs are environment specific. The density of wells tends to be more concentrated around centres of population, more evenly distributed outside the towns and villages, and least concentrated in the vicinity of surface waters such as Llyn Alaw [SH 39 86]. Thus, for example, there are clusters of wells around Gwalchmai [SH 38 76] and between Llanfechnell and Mynydd Mechell [SH 36 90] as well as the northern outskirts of Llangefni [SH 46 76] which is at the margin of the survey area. The distribution of springs is constrained not by social needs but by geology and topography.

Analysis of the density distribution of both springs and wells for each bedrock formation is given in the **distribution of springs and wells table**. The dataset includes those wells and springs that derive water only from the superficial cover and from the contact between till and bedrock. As the

till coverage is near complete, the drift wells and springs are likely to be roughly evenly distributed. The overall well and spring densities, be they in bedrock or drift, mainly reflect changes in bedrock properties, the Quaternary properties being areally consistent.

Distribution of springs and wells in north-east Anglesey by geological formation (after Robins and McKenzie, 2005).

	Bedrock geology	Area (km ²)	Total wells and springs		Wells		Springs		Total Wells		Springs km ⁻²
			number	%	number	%	number	%	km ⁻²	km ⁻²	
Carboniferous	Carboniferous Limestone facies	28	81	5	36	3	45	8	2.9	1.3	1.6
Devonian	Old Red Sandstone	8	21	1	10	1	11	2	2.5	1.2	1.3
Silurian	Llandoverly	1	4	0	2	0	2	0	6.7	3.3	3.3
Ordovician	Ordovician (undifferentiated)	113	392	22	243	20	149	27	3.5	2.2	1.3
Monian Complex	South Stack Group	18	95	5	77	6	18	3	5.2	4.3	1.0
	New Harbour Group	133	465	26	373	30	92	17	3.5	2.8	0.7
	Holyhead Quartzite Formation	3	3	0	3	0	0	0	1.2	1.2	0.0
	Gwna Group	61	249	14	183	15	66	12	4.1	3.0	1.1
	Church Bay Tuffs and Skerries Grits	13	59	3	45	4	12	2	4.4	3.4	0.9
	Central Anglesey Shear Zone and Berw Shear Zone	28	91	5	58	5	33	6	3.2	2.0	1.2
	Coedana Complex	38	149	8	88	7	61	11	3.9	2.3	1.6
	Coedana granite	29	113	6	76	6	37	7	3.9	2.6	1.3
	Totals		480	1771	100	1225	100	544	100	3.7	2.5

The **distribution of springs and wells table** shows that there are 3–4 springs and wells per km² in north-west Anglesey. In the Precambrian, the density of wells is greatest over the South Stack Group and least over the Holyhead Quartzite Formation, whereas the springs are more evenly distributed across the Monian Supergroup although none were found over the Holyhead Quartzite Formation. This suggests that the New Harbour Group and South Stack Group and other formations in the Monian Supergroup offer more favourable conditions for shallow groundwater than the Holyhead Quartzite Formation. The Palaeozoic and Precambrian strata have a similar distribution density of wells and springs except for the Holyhead Quartzite Formation, which has poor hydraulic properties.

There are a number of additional features that the data illustrate. Increased fracturing in the vicinity of dolerite dykes accounts for the success of well digging in much of the South Stack Group, which has 4–5 wells per km², but only 1 spring per km², and the New Harbour Group, which has 2–3 wells per km² and 1 spring per km². The presence of distinct foliation in the Gwna Group and the Church Bay Tuffs and Skerries Formation also enhances the success of well digging in these rocks. In all the other formations the proportion of wells to springs is more equally divided, as there are fewer fractures and other minor discontinuities which favour the successful development of wells.

Available hydrochemical data for the Gwna Group indicate a weakly mineralised oxic group of

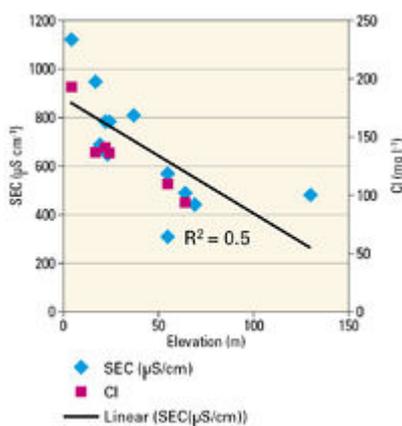
waters that tend to be influenced by the prevailing maritime environment with elevated Na and Cl concentrations (typically 18 mg l⁻¹ and 31 mg l⁻¹ respectively). The waters are mostly Ca-HCO₃ type with subordinate Ca-Cl dominance with specific electrical conductance generally around 361 μS cm⁻¹ derived from 32 samples ([Banks et al., 2007](#)).

South of Bangor is the Padarn Ridge, stretching from Penygroes to Bethesda. It rises to just above 350 m above OD, and comprises hard tuffs and agglomerates of the Padarn Tuff Formation, the basal member of the late Precambrian to Cambrian Arfon Group. Small springs issue from the bedrock along the flanks of the ridge and many of these have been used for domestic supply. There are no water wells or boreholes recorded in the formation. The Ffynnon Springs [SH 4948 5642] lie at an elevation of 180 m on the north-western flank of the ridge. The major ion chemistry of the discharge ([Welsh Office Agriculture Department, 1986](#)) indicates a small catchment containing a young, immature, and weakly mineralised groundwater (Ca 14 mg l⁻¹; Na 16 mg l⁻¹; Mg 2.4 mg l⁻¹; Cl 25 mg l⁻¹; Na 16 mg l⁻¹; NO₃ 16 mg l⁻¹; K 2.4 mg l⁻¹) These concentrations are typical of the short and shallow flow paths that occur in fractured basement rocks.



Bardsey Island.

A small study of groundwater sources in the Gwna Group in Bardsey Island was reported by [Webb \(2000\)](#). The island has an area of only 178 ha and is nearly 3 km long and 1 km wide, and rises from lowlands in the west to a summit at Mynydd Enlli of 167 m (**Plate P802418**). Many of the numerous springs are ephemeral with yields measured in September 1998 up to 2.0 l s⁻¹ but typically less than 0.3 l s⁻¹ (these spring yields may increase in the winter months). Surface drainage is only maintained throughout the year on some of the lower-lying areas in the west. Throughout the island the water table is nowhere deeper than 0.6 m although pumping water levels may be deeper. Slug tests at auger holes in the shallow weathered zone indicate that the hydraulic conductivity is of the order 10⁻³ m d⁻¹.



Bardsey Island: Specific Electrical Conductance (SEC)/Cl to elevation

relationship in groundwater
(See Webb, 2000). P859261.

Sampling and analysis of selected sources for inorganic determinands indicates a generally weakly mineralised Na(Ca)-Cl type groundwater. Mineralisation is least at higher altitudes and greatest at lowest altitudes (**Figure P859261**) indicating a strong marine influence as indicated by the dominant Cl ion (cf. [Webb \(2000\)](#)).

Investigation of and information on the groundwater potential in the Precambrian rocks in Lleyn and in Pembrokeshire is limited. For the most part, stream flow run-off is neutral to marginally acid ([British Geological Survey, 2000](#)) with little buffering offered by weakly mineralised baseflow. However, outcrop areas are small and the controlling elements are the younger rocks that are present in respective catchments. There are no records of boreholes and wells in the Precambrian rocks in Lleyn and Pembrokeshire although it is likely that spring discharges draw on small groundwater catchments.

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