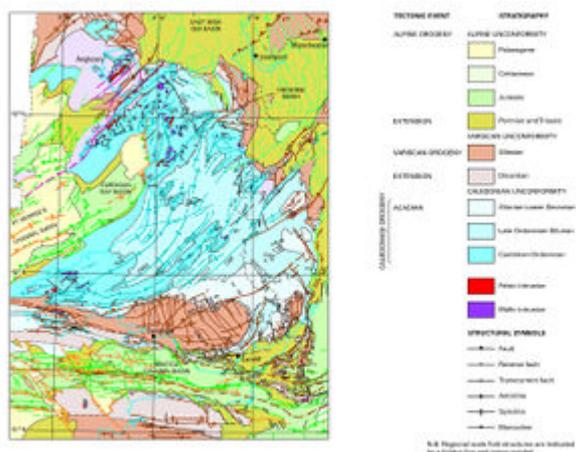


Caledonian orogeny, Silurian, Wales

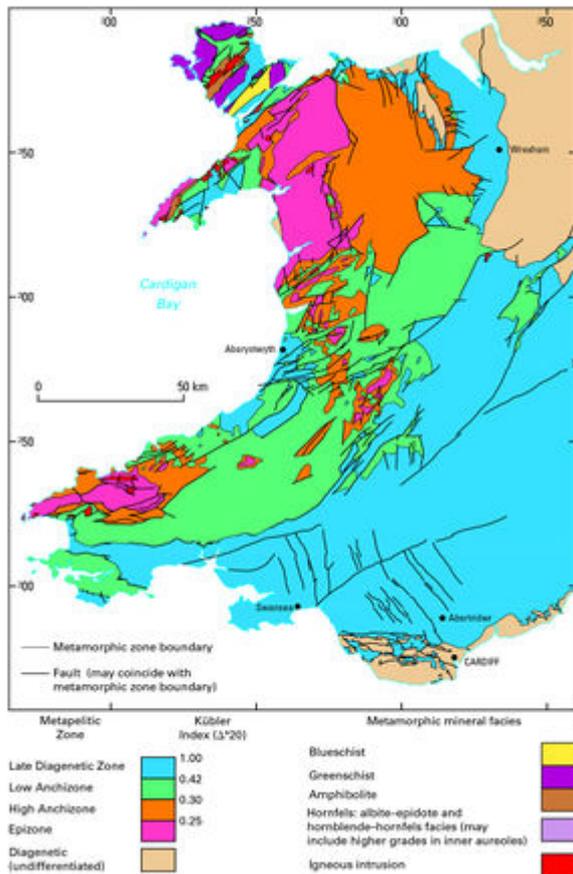
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[Jump to navigation](#) [Jump to search](#)

From: Howells, M F. 2007. [British regional geology: Wales](#). Keyworth, Nottingham: British Geological Survey.



Tectonic map of Wales — key opposite (adapted from BGS, 1996). BD Berwyn Dome; BF Bala Fault; CSF Church Stretton Fault; CVF Conwy Valley Fault; CWS Central Wales Syncline; DS Dolwyddelan Syncline; HD Harlech Dome; LS Llyn Syncline; LsS Llanystumdwy Syncline; LSZ Llyn Shear Zone; ML Malvern Lineament; MSF Menai Straits Fault; ND Neath Disturbance; PL Pontesford Lineament; SS Snowdon Syncline; TA Tywi Anticline; TeA Teifi Anticline; UA Usk Anticline. Inferred age of structures: magenta Precambrian to Early Palaeozoic; blue Acadian; brown Variscan; green Mesozoic; orange Cainozoic (mainly Alpine). Key to Figure 31. P916176.



Metamorphic map of Wales (data collated by R J Merriman, see Merriman, 2006). P916177.

The Lower Palaeozoic rocks that accumulated in the Welsh Basin have been assigned to the 'paratectonic' (nonmetamorphic) Caledonides. Nevertheless, the contemporaneous movements and unconformities throughout Lower Palaeozoic times were the relatively gentle precursors of the intense tectonic activity that occurred at the culmination of the Caledonian orogeny — the Acadian phase of deformation that occurred towards the end of the Early Devonian. The orogeny resulted from the oblique collision of the continents of Eastern Avalonia and Laurentia following closure of the intervening Iapetus Ocean. In Wales, progressive collision, from late Silurian to mid-Devonian times, resulted in deformation (P916176) and low-grade metamorphism (P916177) of the Lower Palaeozoic sequence, and the inversion of the basin.

The original development of the basin in late Precambrian times was greatly influenced by fractures that had previously contributed to the construction of the basement mosaic. The north-west margin of the basin was broadly coincident with the Menai Straits Fault Zone, and the south-east margin with the Welsh Borderland Fault Zone; tectonic activity in both these zones, and the similarly aligned Bala Fault Zone, continued to affect sedimentation patterns throughout Lower Palaeozoic times. However, between these major features there are many similar lineaments that contributed progressively to the geological evolution. The development of the broadly north-south-orientated complex anticline in the Cambrian strata of the Harlech Dome was probably constrained by flanking lineaments which had previously distinguished a major centre of deposition; similar orientations are displayed in the fault-controlled Conwy valley and Vale of Clwyd. During Ordovician times in Snowdonia, the development of volcanic activity was controlled by the north-east-south-west-orientated Beddgelert Fracture Zone and the distribution was constrained by the marginal faults of the larger, similarly aligned, Snowdon Graben. On the south side of Snowdonia, the magnetic

anomalies across the strikingly featured Bala Fault Zone are most easily interpreted as contrasting basement rocks. Activity continued on the fault affecting the cover rocks for some considerable time.

Within the Silurian outcrops, four prominent lineaments have been distinguished, from west to east, the Glandyfi, Central Wales, Tywi and Pontesford lineaments. The north-trending Glandyfi Lineament, in the Aberystwyth district, marks a regional divide in fold vergence and is coincident with a major fracture, the Bronnant Fault. Contemporaneous movement along this fault caused profound westwards thickening of the Aberystwyth Grits Group. Similarly, the Central Wales Lineament, situated along the axial zone of the Central Wales Syncline, influenced early Silurian sedimentation patterns.

The Tywi Lineament, broadly coincident with the axial zone of the intensely faulted Tywi Anticline, was most active in early Silurian (Telychian) times. The Garth Fault, at the eastern end of the anticline, separated the shelf and basal sequences during Ashgill and Silurian times, and defined the eastern limit of the pervasive Caledonian (Acadian) deformation. Locally, the Tywi Lineament lies close to the Pontesford Lineament but the latter is associated mainly with a series of north-east-trending faults in the Ordovician inliers at Shelve and Builth. Throughout the basin, there is a plexus of syndepositional and postdepositional faults between these major lineaments.

All the lineaments are considered to reflect the reactivation of basement fractures and their upward propagation into the cover sequences. In their early manifestation, during basement construction, strike-slip movement was probably important, but subsequent movement, in early Palaeozoic times, was predominantly vertical, although there is some evidence, as in the Builth Wells inlier, of strike-slip movement in the late Ordovician. Several of the lineaments influenced the location and form of the later Caledonoid structures, which, in addition, were affected by the lithological contrasts. These effects are most clearly expressed in the contrasts between the Silurian maps of central Wales, in dominantly mudstone sequences, and the Cambrian and Ordovician maps of north Wales, where thick beds of competent sandstones, extrusive volcanic rocks and irregular intrusive bodies are intercalated with the mudstone sequence.

The Central Wales Syncline is flanked, to the west and east respectively, by the Teifi and Tywi anticlines ([P916176](#)), and these complex open folds can be traced to the southwest into Pembrokeshire where the orientation is generally closer to east-west. When traced into north Wales, the patterns of the folds are less clearly defined. The main syncline persists into the vicinity of the Bala Fault, which separates the north-south-orientated Harlech Dome, in the west, from the broadly east-west-orientated Berwyn Dome and Llangollen Syncline, in the east. North of the Vale of Ffestiniog, the structures are clearly influenced both by the vicinity of the Menai Straits Fault System and the thick competent Precambrian strata of the Bangor and Padarn ridges. The dominant structure is the main, north-east-south-west Snowdon Syncline(s), flanked to the west by the Llanystumdwy and Llŷn synclines and, to the east, by the east-west-orientated, overturned, Dolwyddelan Syncline; this complex synclinorium (nest of synclines) lies entirely within Ordovician strata. In marked contrast is the broad, open, east-west synclinal flexure in the Silurian strata to the east of the Conwy Valley Fault. On Anglesey, the Lower Palaeozoic rocks are strongly folded and overthrust, with the south-east vergence that characterises most of the Caledonoid folds across Wales.

Most of the Lower Palaeozoic rocks of Wales are cleaved and, at any one locality, the cleavage is more closely spaced and more pervasive in mudstones than in adjacent sandstones. Throughout the Lower Palaeozoic sequence, the single penetrative cleavage (S_1) is ubiquitous but its orientation and attitude is highly variable. Locally it is overprinted by a crenulation cleavage (S_2). Cleavage planes are generally defined by foliae of aligned phyllosilicates (micas), opaque and secondary minerals that separate thin laminae of non-foliated quartz, chlorite and muscovite. It is the cleavage in the

mudstones that resulted in the development of the slate industry through Wales in the early 19th century, and which subsequently has had such a profound affect on the social, economic and cultural life. The extraction occurred throughout the Lower Palaeozoic sequence: in the Lower Cambrian rocks of Bethesda–Nantlle, the Upper Cambrian on Llŷn, the Lower Ordovician at Blaenau Ffestiniog and Pembrokeshire, the Upper Ordovician at Corris and Aberllefenni, the Lower Silurian near Machynlleth, and Middle Silurian at Corwen and Llangollen. Such a concentration of slate extraction in such a small area must be unique. The cleavage varies from a spaced, discontinuous fabric in areas of low grade metamorphism to a closely spaced and more pronounced fabric in the higher grade areas. Most commonly, the cleavage is axial planar to the main folds and generally fans across them. However, locally in north Wales and more generally in the mudstone sequences of central Wales, cleavage transects the axial trace of the folds. For example across the Teifi Anticline and to the west of the Bronnant Fault, there is a systematic change in clockwise transection from 10° to 16° in the north to 4° to 7° in the south. It has been suggested that such clockwise transected folds reflect sinistral transpressive deformation, although the evidence in the Welsh Basin is still equivocal.

The determination of the age of the cleavage has been problematic, but recent work suggests that, in places, it was initiated at an early stage in the deformational history. Also, there is evidence that cleavage was being developed in parts of the basin when other areas were still receiving sediment. It seems likely that compression and the geothermal gradient caused the cleavage to develop progressively through the thick basal sequence. There is a consensus that the main influence on cleavage development was during early to mid Devonian times (Emsian or Eifelian stages). Cleaved red beds of Přídolí age have been recorded along the Pontesford Lineament and on Anglesey.

The Lower Palaeozoic rocks suffered low-grade, mainly subgreenschist, regional metamorphism during the end-Caledonian orogeny. Nowhere have the original fabrics been obliterated. The most sensitive indicator of metamorphic grade is white mica (crystallinity), which is the dominant mineral of the mudstones, the main sedimentary component within the basin ([P916177](#)). There is a decline in white mica crystallinity from older into younger rocks: the Cambrian strata are epizonal (low greenschist facies) while Ordovician and Silurian strata are anchizonal (pumpellyite basite facies). However, this simple depth of burial pattern can be modified by inhomogeneous strain, as would be expected in strained mudrocks adjacent to the steep limbs of folded competent layers, crystallinities would be enhanced.

Platy and fibrous stilpnomelane occur in pressure shadows around opaque iron ore grains and along iron oxide residues on pressure solution seams. Porphyroblasts of chloritoid, diagnostic of greenschist facies, are irregularly distributed in high anchizonal rocks. The metamorphosed basic rocks comprise ‘unbuffered’ assemblages of chlorite, actinolite, epidote, calcite and leucoxene, and are of little use in determining pressure/temperature conditions. However less altered assemblages do occur in the centre of some intrusions and the absence of prehnite implies that pumpellyite-actinolite facies conditions were obtained — approximately 325° and 2.25 kilobars pressure.

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Contents

[Introduction](#)

[History of geological research](#)

[Geotectonic setting](#)

Precambrian and ?Cambrian

Monian Composite Terrane

Coedana Complex

Blueschist Terrane

Monian Supergroup

Avalon Terrane

South-west Wales and the borders

Cambrian

Comley Series

St David's Series

Merioneth Series

Ordovician

Tremadoc

Arenig

Llanvirn

Caradoc

Ashgill

Ordovician volcanism

Silurian

Llandovery

Wenlock

Ludlow

[Přidolí](#)

Caledonian orogeny

Devonian

[Lower Old Red Sandstone](#)

[Lochkovian](#)

[Pragian—Emsian](#)

[Upper Old Red Sandstone](#)

Carboniferous

[Dinantian](#)

[Tournaisian](#)

Visean

Silesian

Namurian

Westphalian

Coal

Variscan orogeny

Mineralisation

Mesozoic

Permian—Triassic

Jurassic

[Lower Jurassic](#)

[Middle Jurassic](#)

[Upper Jurassic](#)

[Cretaceous](#)

[Lower Cretaceous](#)

[Upper Cretaceous](#)

[Oil and gas](#)

[Cainozoic](#)

[Palaeogene—Neogene](#)

[Quaternary](#)

[Pleistocene](#)

[Holocene](#)

[Geology and man](#)

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[Category](#):

- [Regional Geology of Wales](#)

Navigation menu

Personal tools

- Not logged in
- [Talk](#)
- [Contributions](#)
- [Log in](#)
- [Request account](#)

Namespaces

- [Page](#)
- [Discussion](#)

Variants

Views

- [Read](#)
- [Edit](#)
- [View history](#)
- [PDF Export](#)

□

More

Search

Navigation

- [Main page](#)
- [Recent changes](#)
- [Random page](#)
- [Help about MediaWiki](#)

Tools

- [What links here](#)
- [Related changes](#)
- [Special pages](#)
- [Permanent link](#)
- [Page information](#)
- [Cite this page](#)
- [Browse properties](#)

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