Variscan orogeny, late Carboniferous, Wales

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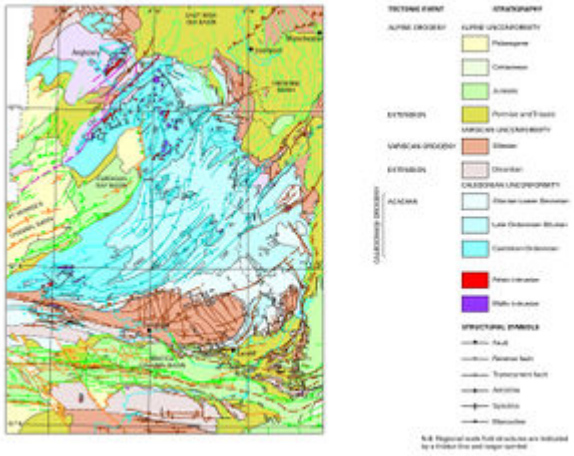
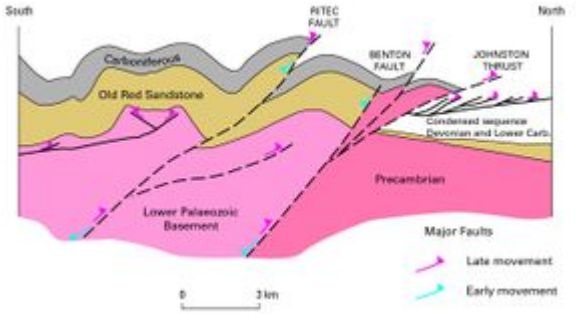


Tectonic map of Wales — key opposite (adapted from BGS, 1996). BD Berwyn Dome; BF Bala Fault; CSF Church Stretton Fault; CVF Conwy Valley Fault; CWS Central Wales Syncline; DS Dolwyddelan Syncline; HD Harlech Dome; LS Llyn Syncline; LsS Llanystumdwy Syncline; LSZ Llyn Shear Zone; ML Malvern Lineament; 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). P916176.

Monoclinal fold disrupted by small thrust, Lower Coal Measures north of Broadhaven. P662431.



Cross-section illustrating Variscan structures in Pembrokeshire (adapted from Powell, 1989). P916197.

The movements that periodically affected sedimentation through Devonian and early Carboniferous times in Wales were the precursors of the Variscan Orogeny, which climaxed in the late Carboniferous; the orogeny was caused by the collision between the Laurussian and Gondwanan plates. In early Devonian times, rifting developed passive marginal basins in south-west England and elsewhere, and these accumulated marine Devonian and Carboniferous sedimentary and volcanic rocks. Progressive convergence, beginning in mid-Devonian times, inverted these basins and thrust them northwards. The movement caused flexural subsidence ahead of the deformation front and the development of a foreland basin in south Wales, which accumulated detritus eroded from the fold and thrust belt to the south. It is only in the Devonian and Carboniferous sequences in south Pembrokeshire, the Gower and south Glamorgan, that the typically east–west-trending Variscan structures can be clearly distinguished (P916176). Two zones of deformation lie on either side of the Variscan Front, a putative line that defines the limit of strong deformation. To the south of the front, the deformation is typical of a fold and thrust belt, particularly in south Pembrokeshire where the Devonian and Carboniferous strata are weakly cleaved and altered to the lowest anchizonal grade of regional metamorphism. To the north of the front, thrusting is more variable, folds are more open (P662431) and the rocks are non-metamorphosed.

In Pembrokeshire, south of Milford Haven, the Ordovician and Namurian sequences are intensely folded. The steep-limbed folds have axes that trend close to an east–west orientation; strata in the anticlines range down to Llanvirn age, and in the synclines, as at Bullslaughter Bay, the cores are of Dinantian and Namurian strata. Axial and limb buckling is extremely common, several minor thrusts replace minor folds and fold axes are displaced by several, post-folding cross-faults as in Stackpole Quay. Within the Upper Carboniferous sequence, the Precambrian Johnston Complex and Benton Volcanic Group have been thrust northwards on the Johnston Thrust for some 4 km over the Westphalian (P916197).

The Johnston–Benton fault belt and the Ritec Thrust dominate the structure of south Pembrokeshire, as high-level, thin-skinned Variscan features, and the trace of the Ritec Thrust subsequently influenced the erosion of Milford Haven. However both structures had probably influenced sedimentation, as major growth faults in a pre-Variscan extensional regime, since early Silurian (late Llandovery) times; the effect of the Variscan compression was to overprint contractional features at their upper levels. Farther east, the Johnston Thrust can be distinguished in the cliffs at Amroth and from here it can be projected into the broadly north-easttrending, Llandyfaelog–Carreg Cennen Disturbance close to the north edge of the main coalfield.

Within the main coalfield, the complexity of the main Variscan deformation has been most manifestly displayed in the open cast sites; local shortening estimates up to 50 per cent have been proposed, but overall are closer to 30 per cent. Throughout the central and northern coalfield a forethrust system developed, which was balanced by a major backthrust system along the south crop. Many thrusts have been distinguished, particularly in the anthracite 'belt', between Ammanford and the Gwendraeth valley, and in the south crop. The dip along many of these faults steepens markedly, as from 20° to 70° along the Ty’n y Nant and Moel Giliau fault sytems. These structures were controlled by the variable competence of the sedimentary rocks; the competent sandstones of the Pennant Sandstone Formation acted as a passive roof to the thrust system.

To the east of Pembrokeshire, the front is more difficult to delineate although it can be traced close to the north side of the Gower and farther into the Vale of Glamorgan. Within Gower, the folds are not as closely packed as in Pembrokeshire, but vertical and overturned strata, as in the south cliffs of Rhossili Bay, are not uncommon. The major anticlines, as at Rhossili Down and Cefn Bryn, preserve Devonian strata in their cores, while the synclines, as at Oystermouth and Port Eynon, preserve Namurian beds. Parallel thrusts and cross-faults, although present, are not as apparent as farther west. Pre-existing structures beneath the south crop were the main influence in determining the backthrust system and the Variscan folds in the Vale of Glamorgan at the edge of the mountain front.

The syncline of the main basin of the coalfield is most clearly defined east of Llanelli. The wide outcrop patterns, for most of the north crop, and the narrow outcrops, of the east and south crops, reflect its general asymmetry, but there are many local complexities. Within the main syncline, en échelon minor folds, such as the Pontypridd and Maesteg anticlines, and the Caerffili, Gelligaer and Llanelli synclines, progressively deflect into a north-easterly trend as they are traced eastwards into Monmouthshire.

Faults are an important element in the structure of the coalfield and many caused major problems in the extraction of the coal. The dip or cross-faults are the most obvious, predominantly north-north-west-trending in the western and central parts of the coalfield and gradually deflecting to more north-westerly trending in the eastern parts. Many of these faults developed during folding whereas others postdate folding. Two of the most distinctive structural features of the main coalfield, the Neath and Swansea valley disturbances, are northeast–south-west zones of folded and faulted strata that trend into the coalfield from the Devonian outcrops to the north and east (P916176). The Neath

Disturbance is marked by intense folding of lower Carboniferous strata, as at Penderyn and Craig y dinas. Similar folding, as at Cribarth, marks the Swansea Valley Disturbance. The Neath and Swansea valley disturbances bear a close similarity to the Carreg Cennen Disturbance, which emerges from Devonian strata near Pendine and passes laterally into the Johnston Thrust, in the Coal Measures, near Amroth (see above). The zones clearly represent a long history of pre-Variscan and probably post-Variscan tectonic activity, which suggests they were propagated by basement fractures.

The clear determination of Variscan structures in the areas of central and north Wales, where there are no outcrops of Upper Palaeozoic strata, is impossible. However, it is safe to assume that most of the earlier Caledonoid structures were accentuated in some way. This is supported by the general disposition of the Carboniferous strata marginal to the Lower Palaeozoic landmass, from Oswestry through to Colwyn Bay and Llandudno to Anglesey, which suggests considerable upwarping of major structures such as the Harlech Dome and the Derwen Anticline. Reactivation of the Bala Fault Zone is most graphically demonstrated by its extension, in the Bryneglwys Fault, through to Caergwrle, and its sinistral displacement of the Carboniferous sequence. Similar reactivation is apparent in the displacement of the Lower Carboniferous sequences along the Vale of Clwyd faults, the Menai Straits Fault System, and marginal to the Berw Fault, at Malltraeth, on Anglesey.

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