Geotectonic setting of Wales


Distribution of continents in Late Proterozoic and early Palaeozoic time. Note: England and Wales are greatly exaggerated in size (adapted from Mitchell, 2004). P916144.

Terranes of the Caledonian and Variscan orogens (adapted from Cope et al., 1992).
The original books in this British Regional Geology series, published in 1935 and 1937 respectively, and the revised editions of 1961 and 1975, were not influenced by plate tectonic theory, which was established in the late 1960s. The theory is the most revolutionary concept in geological thinking since Darwin and Wallace presented their separate papers on the theory of evolution by natural selection to the Linnean Society in 1858. The plate tectonic theory proposes that the surface of the Earth comprises half a dozen or so large plates, which are continuously in motion with respect to each other. It developed from the recognition that areas occupied by the oceans have grown and expanded as magma rose along deep fractures in the Earth. At the surface the magma cools and solidifies to form mid-ocean ridges and new oceanic crust spreads slowly from the axis of the ridge. This crust eventually collides with, and pushes under, the adjacent continental plate (subduction). These processes continuously rearranged the crustal plates throughout the Earth’s history.

During late Precambrian and early Palaeozoic time, England, Wales and south-east Ireland lay on a segment of Eastern Avalonia at the edge of the continent of Gondwana, and Scotland and north-west Ireland lay farther north across the Iapetus Ocean at the margin of Laurentia (P916144). At the same time, Scandinavia and northern Europe lay on a small plate, Baltica, which was separated from Laurentia by the Iapetus Ocean and from Eastern Avalonia by the Tornquist Sea.

The Precambrian rocks of Eastern Avalonia, the basement to the Lower Palaeozoic sequence in Wales, comprised several crustal blocks or terranes of arc-magmatic rocks and sedimentary basins that had been accreted to the edge of Gondwana in late Precambrian times, 680 to 545 Ma. During most of Cambrian times, tectonic movements continued to modify the edge of Gondwana and in early Ordovician (Tremadoc) times subduction of oceanic crust beneath Eastern Avalonia, marked by island-arc volcanic activity, was associated with its separation from Gondwana and its drift northwards. Throughout Ordovician times, Wales was the site of a back-arc basin with voluminous calc-alkaline basaltic and rhyolitic volcanism. It was flanked on its south-eastern margin by the Midlands Platform, and the volcanic arc, forming the northern margin of the basin, extended from south-eastern Ireland to the Lake District. In late Ordovician times, the cessation of major volcanism suggests the initiation of the collision between Eastern Avalonia and Laurentia, which is supported by the faunal evidence. The basin continued to accumulate thick sequences of marine sediments throughout Silurian times.

The progressive convergence of the Avalonia and Baltica plates with Laurentia resulted in collision and the Caledonian orogeny. In Wales, this tectonic event was initiated in mid to late Silurian times (P916144) and led to localised deformation and uplift. However, the main effects occurred in early to mid Devonian times when the Welsh Basin was inverted, and the accumulated sedimentary and volcanic rocks were folded, metamorphosed and uplifted. This Acadian phase of the Caledonian orogeny completed the amalgamation of Laurentia, Eastern Avalonia and Baltica, at about 400 Ma. It imposed a series of north-east-trending folds and associated cleavage belts as the dominant tectonic grain on the Lower Palaeozoic rocks.

The Caledonian terrane amalgamation formed the supercontinental plate, Laurussia, which began to converge with Gondwana, to the south, causing northward subduction of the intervening Rheic oceanic crust and, in turn, the formation of a series of rift basins across much of Britain. Initially these basins accumulated detritus shed from the uplifted Caledonian mountain chain, the thick continental ‘Old Red Sandstone’ deposits of the Devonian, and then the limestone, deltaic deposits and coals of the Carboniferous. The collision of Laurussia and Gondwana caused the Variscan orogeny, which is reflected in a mountain belt from Russia across Europe into North America, and their amalgamation into the supercontinent of Pangaea. Most of Wales lay to the north of the collision zone but the advancing deformation front controlled tectonic development across the
region. A putative line, the Variscan Front (P916145), marking the limit of strong deformation, crosses the Bristol Channel and south Wales, following a west-north-west trend across Swansea Bay and Carmarthen Bay. To the south of the front, on Gower and south Pembrokeshire, Upper Palaeozoic rocks have been strongly folded. North of the front, the Wales–Brabant Massif extended across the English Midlands into Belgium. To the north of this landmass, the Carboniferous rocks in north Wales accumulated in a series of extensional basins linked to the Pennines Province.

Following the construction of Pangaea, thermal relaxation of the crust resulted in the formation of a series of rift zones, which eventually fragmented the supercontinent. About the uplands of Wales, the stress created the graben-like East Irish Sea, Worcester and Cheshire basins. Simultaneously, the tropical coal-generating swamps of late Carboniferous times were replaced by the arid desert conditions of the Permian and Trias. The continental fragmentation of Pangaea, and subsequently Gondwana, continued to influence late Mesozoic basin development in Britain in response to the Alpine orogeny, which was caused by the collision of the northern edge of Africa with the European (Eurasia) continent in Late Cretaceous times. On the margins of the Welsh massif, extensional basins, which formed during Jurassic times, continued to accumulate thick sequences of sediments into the Quaternary.

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