



Non-Marine Devonian (NMAR-DEV)

Block Description

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Introduction

The GCR sites selected for this GCR Block represent the British geological record of Earth history from about 417 to 354 million years ago (Ma) as represented by non-marine rocks called the 'Old Red Sandstone' of Devonian Age. Old Red Sandstone strata of Prídolí (Silurian) age (419–417 Ma) are afforded their own GCR Block (see **Pridoli (PRIDOL)** and discussion below). Strata laid down in the Devonian Period (the fourth Period of the Palaeozoic Era, 540–251 Ma) constitute the Devonian System. Traditionally, the Old Red Sandstone rocks in Britain were regarded as wholly Devonian age, and as the terrestrial equivalents of the marine Devonian rocks of south-west England (see **Marine Devonian (MAR-DEV)**). The age intervals, or stages, of the Devonian Period, defined in the marine rocks of continental Europe, can be applied to the terrestrial Old Red Sandstone succession, albeit with some difficulty because of its absence of marine fossils.

In the past, the base of the Old Red Sandstone was placed at the base of the Ludlow Bone Bed, a very thin, lenticular, phosphatised lag deposit present marking the top of the Silurian Ludlow Series in South Wales and the Welsh Borderland. However, the modern definition of the base of the Devonian System (in the Czech Republic, at the base of the *Monograptus ultimus* Biozone) now places the basal parts of the Old Red Sandstone succession in the Silurian System. The strata from the Ludlow Bone Bed up to the base of the Devonian, as yet poorly defined in the Old Red Sandstone, belong to the Pridoli Series, the fourth, uppermost series of the Silurian System see **Pridoli (PRIDOL)**.

The Old Red Sandstone is one of the two major red-bed sedimentary unit in Great Britain, the other being the younger Permo-Triassic rift basin-fill, formerly termed the 'New Red Sandstone' (see **Pridoli (PRIDOL)**) to distinguish it from the Old Red Sandstone.

Outcrop pattern

The Old Red Sandstone rocks crop out principally in four main areas in Great Britain, which broadly reflect the original basins in which they were deposited. These are: the Orkney and Shetland islands and north-east Scotland (the Orcadian Basin); the Midland Valley of Scotland (in an amalgamation of several basins of which the largest was the Strathmore Basin); Northumberland (the Northumberland and Solway basins); and south Wales and the Welsh borderland (the Anglo-Welsh Basin).

Palaeogeography and palaeoenvironment

The Old Red Sandstone represents a period when ocean closure and continental collisions resulted in a world geography hugely different to that of much of the early part of the Palaeozoic Era. The Iapetus Ocean, which separated the northern (Laurentian) and southern (Gondwana) continents during the Ordovician Period closed throughout the Silurian Period as the smaller continent of Avalonia fragmented from Gondwana and drifted northwards. As the Iapetus Ocean closed north of Avalonia, the Rheic Ocean opened behind it. To the east, the continent of Baltica also drifted northwards and eastwards and the Tornquist Sea, an arm of the Iapetus between it and Laurentia, slowly closed. Baltica and the eastern part of Avalonia collided first, in Late Ordovician time, moving northwards together to make first contact with Laurentia in the early part of the Silurian Period. By late Silurian (Ludlow) time, the continents had fully docked, with the Iapetus Ocean closed along the line of subduction (the Iapetus Suture) under the Southern Uplands. Thus, the Caledonian–Appalachian Orogen and the newly amalgamated Old Red Sandstone continent (also named Laurussia and Euramerica) was formed (see **Caledonian Structures of the Lake District (CAL-STR-LD)**). Palaeogeographic reconstructions suggest that the continent lay in tropical to sub-tropical latitudes from the equator to about 30°S. Sedimentological studies of the Old Red Sandstone indicate a warm to hot, tropical setting with rainfall confined to wet seasons. Uplift of the orogen may have caused broad variations in the rainfall pattern, producing periods of wetter and drier climate.

Continuing compression and shortening of the continental crust resulted in the filling to sea level of the Silurian basins, their inversion to upland areas and the establishment of terrestrial conditions in newly developing basins. The oblique angle of impingement of the former Laurentian and East Avalonian continents resulted in sinistral transpressive movement, thrusting along major NE-trending faults, and granitic intrusion, andesitic volcanicity and low-grade metamorphism in northern Britain. The compression in the Laurentian crust, of which the Scottish Highlands were part, was accompanied by the intrusion of large volumes of granitic rocks and the extrusion of predominantly andesitic volcanic rocks (see **Caledonian igneous (CAL-IGN)**, **Old Red Sandstone Igneous (Silurian and Devonian Volcanic Rocks) (ORS-IGN)**).

The Orcadian Basin was a large mid-Devonian intramontane lake basin, totally unconnected to the open sea, apart perhaps from a brief period. The Midland Valley of Scotland was not a single discrete basin in the Devonian. Weakened by a long history of igneous activity, internal, transtensional fault movements opened pull-apart basins and transpressive movements subsequently inverted them, resulting in the recycling of the basin-fills and providing weak points for continuing volcanic extrusion. The preserved sequences thus represent the deposits of separate pull-apart basins, formed and brought together in a strike-slip faulted collage. The Stonehaven Basin in the north-east is the earliest, its fill dating perhaps from the Wenlock Epoch. It and its larger successor basins, the Crawton and Strathmore basins, formed by sinistral strike-slip along the Highland Boundary Fault. The southerly Lanark Basin formed along the Southern Uplands Fault. Large volumes of arc-related volcanic rocks were extruded along the central axis of the Midland Valley, on lines weakened by the transtensional stresses. The late Silurian to early Devonian Solway and Northumberland basins formed in the Southern Uplands Terrane and were probably isolated from the basins of the Midland Valley to the north. The late Devonian Scottish Borders Basin formed after Acadian inversion in the mid-Devonian and extended into the Midland Valley.

The Anglo-Welsh Basin is interpreted primarily as the product of load-generated flexural subsidence of the Caledonian foreland. Superimposed on this were transtensional and extensional movement on faults that produced variations in the basin fill in Pembrokeshire and introduced coarse clastic detritus farther north. The isolated succession in Anglesey was probably deposited contiguously with the Přídolí sequences to the south, although the initial coarse conglomerates are unique and of local derivation, and lacustrine deposits suggest internal or impeded drainage; the effect of the nearby Caledonoid faults requires examination.

GCR site selection

The four networks covered by this GCR Block are essentially the four main outcrops of the Old Red Sandstone, arranged geographically from north to south, and which correspond to, or closely reflect, the original depositional basins.

- Orcadian Basin
- Midland valley of Scotland
- Northumberland and Solay basins
- Anglo-Welsh Basin

Although the relatively common invertebrate fossils do not have a separate selection category in the GCR in their own right, the scientific importance of many stratigraphy sites lies in their fossil content. Therefore, some of the GCR sites are selected specifically for their fossil fauna, which facilitates stratal correlation and enables the interpretation of the environments in which the animals lived. Moreover, some sites have international significance because they have yielded fossils that are the 'type' material for a taxonomic group.

In contrast to the manner in which most invertebrate fossils are represented in the GCR, fossils of vertebrates, arthropods (except trilobites) and terrestrial plants do have their own dedicated selection categories, owing to the relative rarity of the fossil material.

See Arthropoda (APD); Silurian - Devonian Chordata (SIL-DEV-CH); Palaeozoic Palaeobotany (PAZ-PALBOT); Palaeoentomology (PALENT).

Palaeontology, fauna and flora

In the Devonian Period there are biostratigraphical zonal schemes for graptolites, ammonoids, brachiopods, fish, conodonts, microvertebrates and miospores.

The problems of classification and correlation of the Old Red Sandstone of Britain are inherent in its terrestrial origins and the patchy preservation of its non-marine fossils.

The fossils that are present indicate that the Devonian Period saw profound changes in the evolutionary record, with the first significant colonisation of terrestrial habitats by vascular plants, the rapid expansion of the first aquatic vertebrates, and their emergence onto land. However, no direct correlations can be made with the European marine successions and the internationally agreed stages. Because of this, a series of loosely defined local stages (Downtonian, Dittonian, Breconian and Farlovian) were erected for the Anglo-Welsh Basin. Although now largely subsumed into the international stages as a result of increasing refinement in correlation, they continue to be used as a matter of convenience in describing the Anglo-Welsh succession.

The principal macrofossils of stratigraphical use are fish fragments. Miospore classifications and microvertebrate classification also aid correlation and stratigraphical resolution.