Cambrian (CAM)

Block Description

Visit https://jncc.gov.uk/gcr-site-list, for more information on GCR blocks and sites
For Palaeozoic Stratigraphy GCR block descriptions and GCR site lists,
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Introduction

The GCR sites selected for this GCR Block represent the British geological record of Earth history from about 545 to 495 million years ago (Ma). This interval is the first period of the Palaeozoic Era, which spans from 545 to 251 Ma. Rocks that formed during the Cambrian Period constitute the Cambrian System.

Rocks that range across the Cambrian–Tremadoc boundary (the Tremadoc Epoch being the first of the Ordovician Period, 495–440 Ma) are afforded their own GCR Block (**see Cambrian - Tremadoc (CAM-TRE)**), which includes a small number of sites.

The Cambrian and Ordovician rocks of Britain are essentially of marine origin; freshwater and subaerial deposits have been identified only in settings where volcanic edifices were raised above sea level. Within the marine setting there are rocks of the widest variety, from sandstones and limestones of the shoreline and shallow shelves to beds that accumulated in deep basins or on the continental slopes. Transects from shelf to basin are seen in both Cambrian and Ordovician rocks, and examples of shallow- and deep-water deposits are recognized in both Anglo-Welsh and Scottish areas.

The traditional series of the Ordovician System are Tremadoc (oldest), Arenig, Llanvirn, Caradoc and Ashgill (youngest). There are no globally agreed divisions of the Cambrian System, although ‘Lower’, ‘Middle’ and ‘Upper’ are widely used, but not universally defined.

Outcrop pattern

Cambrian: The largest Cambrian outcrops are in Wales, where they represent thick sedimentary accumulations that formed during an early phase of the development of the ‘Welsh Basin’ (see below). The best representation of the Cambrian System in the historical type area of North Wales is in the Harlech Dome, together with the similar sequence as exposed in the small but important outlying area of St Tudwal’s peninsula. In neither of these outcrops is the base of the Cambrian seen. The Arfon area to the north-west presents a less-complete sequence that differs strikingly from that of the Harlech Dome. The contact with the Precambrian there has been claimed as both conformable and unconformable. The main area of Cambrian rocks in South Wales is in the west, around St David’s.

In northern Scotland the Cambrian strata of the ‘Hebridean Terrane’ crop out in a narrow belt nearly 200km long. A small outcrop of possibl Cambrian rocks lies close to the Highland Boundary Fault Complex (part of the Highland Border Complex) farther to the south.

Odovician: In North Wales there are outcrops of Tremadoc rocks important both historically and in relation to the Cambrian–Ordovician boundary. In South Wales there are few outcrops of the Tremadoc and the strata are more akin to the thick successions of the Welsh Borderlands that extend across central England, where, however they are poorly exposed.

In North Wales, Arenig to Ashgill stratigraphy is dominated by successions reflecting a series of volcanic episodes, with the interfingering of sedimentary and volcanic units.

The Ordovician strata in the county of Shropshire appears in two main areas and adjoining parts of Wales. To the west of the Long Mynd horst, the lower half of the Ordovician succession is thickly developed in the Shelve area on the downthrown side of the Linley–Pontesford Fault. To the east, on the east side of the Church Stretton Fault, the classic Caradoc area exposes almost the whole of the Caradoc Series. Apart from the Tremadoc strata, the Ordovician stratigarphy is little known over most of central England.

In the ocean-facing setting of northern England, Ordovician rocks crop out in the main Lake District Inlier and in the smaller Cross Fell, Cautley and Craven inliers, which are brought up along the Pennine, Dent and Craven fault systems. In both the Lake District and Cross Fell the Skiddaw Group successions are followed unconformably by thick arc volcanic rocks, notably the Borrowdale Volcanic Group of possible late Llanvirn to early Caradoc age. These are overlain, again unconformably, by marine sediments of mid-Caradoc age, and the fullest

knowledge of the succession from the mid-Caradoc to the top of the Ashgill has been derived in this area by piecing together sections from various of the inliers.

Unconnected with any other outcrop of the British Ordovician is the tiny exposure in south-west England at Gorran Haven in Cornwall.

The Ordovician of northern Scotland is present as part of the foreland sequence of the 'Hebridean Terrane' (see below), where it forms outliers on the Cambrian at Durness and Balnakeil, and also on the Island of Skye. Nearly 200 km south-west of Macduff, at the northern edge of the 'Midland Valley Terrane', there are small outcrops of Ordovician rocks along the Highland Boundary Fault Complex from Arran to Stonehaven. At the southern edge of the Midland Valley Terrane the celebrated Ordovician rocks of the Girvan district is a thick sequence deposited against and over scarps created by steeply dipping south-facing growth faults. In the 'Southern Uplands Terrane' the Ordovician is mainly developed as a thick imbricated succession in the 'Northern Belt', but there are important faulted inliers in the 'Central Belt' to the south.

Palaeogeography and palaeoenvironment

During the Cambrian Period, the microcontinent known as 'Avalonia', which includes the area of England and Wales, Belgium and northern Germany, together with south-east Newfoundland, New Brunswick and other parts of eastern maritime North America, lay far to the south of the equator. It was effectively part of the huge continent of Gondwana at least until Arenig (the second stage of the Ordovician Period) times. During the Ordovician Period, Avalonia migrated northwards to a temperate or sub-equatorial position and was first brought into proximity with the Baltic continent, ultimately to collide with the bulk of the North American continent, known as 'Laurentia'. As Avalonia moved from near polar latitudes to a subtropical position, its climate became modified, effecting changes in sedimentary and biotic environments that are duly reflected in the rocks and the fossils preserved in them. There is evidence from Africa and Arabia of an exceptional episode of glaciation at the end of the Ordovician Period This caused a large, though temporary, fall in sea level and wrought great changes in the marine environment, which in turn brought about a major extinction in marine life.

Throughout the Cambrian and Ordovician periods, Scotland lay in the tropics at the margin of Laurentia and during most of this time was separated from Avalonia by the wide ocean known as the Iapetus Ocean. Scotland is made up of discrete fragments, or terranes, that were assembled progressively by strike–slip movements and were welded together during the collision of Laurentia with Avalonia and Baltica during the Caledonian Orogeny (**see Caledonian igneous (CAL-IGN), Caledonian Structures of the Lake District (CAL-STR-LD)**). The early Palaeozoic history of Scotland is therefore very different from that of England and Wales, though during the later Ordovician the convergence of such features as fossil faunas is taken as evidence of the approach of England and Wales to Scotland as the Iapetus Ocean became narrower.

The complex plate-tectonic make-up of Britain has an important bearing on the character and distribution of Cambrian and Ordovician outcrops, because the early history of each tectonic terrane is more or less distinct.

During Cambrian and early Ordovician time, most of Wales and England lay at passive plate margins. Late Precambrian rifting initiated the Welsh Basin, whose infilling constituted the first of the megasequences, the 'Dyfed Supergroup'. The onset of south-east-directed subduction during the early Ordovician saw the development in Wales of a back-arc basin with renewed sedimentation and abundant volcanic rocks. These constitute a second megasequence, the 'Gwynedd Supergroup'. A third megasequence, the Powys Supergroup, commences in upper Ordovician (Ashgill) strata and extends up into the Devonian System. The Welsh Basin, with its relatively thick sequences of basinal rocks, has the largest exposures of Cambrian and Ordovician rocks. The adjoining Midland Platform exposes

thinner shelf sequences in a scattering of relatively small but stratigraphically and historically important inliers. The passive ocean-facing margin in northern England accumulated thick clastic deposits in the earlier Ordovician (mainly Arenig), overlain by thick arc volcanics of about early Caradoc age. A diachronous marine transgression followed, introducing relatively thin neritic deposits. These include a full succession of the higher Caradoc and Ashgill series, in which many sites have been designated, and they form the base to a thick foreland basin succession deposited in the later Silurian.

In the Southern Uplands of Scotland there are thick developments of Ordovician rocks in a basin produced during the closure of the Iapetus Ocean. Adjacent to these outcrops, but separated from them by the Southern Upland Fault, is the famous Girvan district, in which Ordovician successions show striking changes of thickness and facies. The Highland Border area lies along a terrane boundary. It is highly faulted and a uniform stratigraphy is elusive. The Hebridean Terrane in northern Scotland has a foreland margin succession that consists of relatively thin shelf deposits, mainly of Cambrian age.

GCR site selection

When originally selected, the Cambrian and Ordovician GCR sites were organized into stratigraphically thematic GCR Blocks that represented the following: the Cambrian System, the Cambrian–Tremadoc boundary, the Tremadoc Series, the Tremadoc–Arenig boundary, the Arenig to Llanvirn Series, the Llandeilo Series (now the Llandeilian Stage of the Llanvirn Series) and the Caradoc to Ashgill series. This arrangement emphasized the intervals of time represented but does bring together unrelated stratigraphical successions from different tectonic terranes and subdivides regional stratigraphical schemes. It is therefore possible to ascribe GCR sites to GCR networks based upon Cambrian and Ordovician terranes (i.e. frameworks derived from both space and time). The Anglo-Welsh sites, commencing with the Cambrian System, are divisible into North Wales, South Wales and England. The Ordovician System commences with the Tremadoc Series, including the main sites for the Cambrian–Ordovician boundary. The Arenig to the Ashgill strata form a nearly continuous successions in Wales; three regions are represented: South Wales (including the Builth Inlier); North Wales; Shropshire and northern England. Four structural terranes comprise the Cambrian and the Ordovician strata of Scotland.

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.

Palaeontology

Known life during the Cambrian and Ordovician was very largely confined to the marine realm. During this period of Earth’s history, life itself underwent two phases of evolutionary change of the utmost significance. The early Cambrian was the time of the ‘Cambrian evolutionary explosion’, when a great variety of life-forms first appeared in the fossil record. The resulting faunas, which included the first representatives of several groups of animals whose descendents exist today, formed the basis of the ‘Cambrian Fauna’. In the early Ordovician the Cambrian Fauna was largely replaced by the more diverse ‘Palaeozoic Fauna’ wherein a great variety of benthic, nektonic and planktonic organisms appeared, notably during an early to mid-Ordovician evolutionary radiation. Despite suffering a mass extinction at the end of the Ordovician Period, the Palaeozoic Fauna dominated the marine world for the next 250 Ma, the greater part of Phanerozoic history.

Before the end of the Ordovician Period there were marine faunas occupying environments from the intertidal zone to the deep ocean, and there is evidence from the mid-Ordovician for forays into the terrestrial realm.

The most striking faunal differences in the British Cambrian and Ordovician lie in the contrast between the Anglo-Welsh faunas and those of Scotland. Although this contrast, and the affinity of Scottish faunas with those of North America, had been recognized in the middle of the 19th century, it acquired great significance with the development of plate tectonic theory and the proposal of a ‘proto-Atlantic’ ocean, now generally termed the Iapetus Ocean. Generally speaking, Scottish faunas retained their North American similarities throughout the Cambrian and Ordovician periods. Meanwhile, the faunas of England and Wales, which had shown similarities to Gondwana during Cambrian to Arenig time, lost those connections to the south as the Rheic Ocean opened, and during the Caradoc and Ashgill they became more akin to the faunas of Baltica as the Tornquist Sea closed.

In the Cambrian Period the main components of the fossil fauna include brachiopods, trilobites, other arthropods such as bradoriids, gastropod-like molluscs, hyolithids, sponges, echinoderms and paraconodonts. The Lower Cambrian faunas of ‘small shelly fossils’ also include many taxa of uncertain affinity. Most of the foregoing groups also occur, and in greater diversity, in the Ordovician strata, with the addition of other molluscan groups, graptolites, euconodonts and chitinozoa, together with dasycladacean algae. However, from rare instances of exceptional preservation of soft-bodied animals (of which the Canadian Burgess Shale is the most famous), we know that the fossils most commonly preserved represent only a small part of life of the time. Besides ‘body fossils’ (i.e. the remains of actual organisms), Cambrian and Ordovician rocks commonly contain a variety of ‘trace fossils’, that is, tracks, trails, burrows and footprints, representing the activity of animals that may be, or more typically are not, themselves preserved.

The groups most widely used in British Cambrian and Ordovician stratigraphy are brachiopods, trilobites and graptolites.