# Permian - Triassic (PER-TRI)

# 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,
visit https://jncc.gov.uk/gcr-blocks-palaeozoic-stratigraphy

# Introduction

The GCR sites selected for this GCR Block represent the British geological record of Earth history as represented by continental 'red bed' sediments aged from about 291 to 210 million years (Ma) ago. The Permian Period (292–251 Ma) is the last period of the Palaeozoic Era (which spans from 540 to 251 Ma); the succeeding Triassic Period (251–205 Ma) is the first period of the Mesozoic Era (251–65 Ma); this Block does not encompass rocks of Rhaetian Age (the last age of the Triassic Period, 210–205 Ma), which are afforded their own GCR Block (see below). The British Permian and Triassic strata are included in one GCR Block together because they are commonly closely associated in general lithology – over much of England they approximately equate with the old stratal term, 'New Red Sandstone'. (In the early 19th century, all red beds between the readily identifiable marine and coal-bearing Carboniferous and the marine Lower Jurassic strata were termed collectively the 'New Red Sandstone').

Marine Permian GCR sites are selected for a separate Block. **See Marine Permian (MAR-PER**). Therefore this GCR Block encompasses the broad range of desert environments of the Permian and Early to Mid Triassic deposits in Britain, as well as the brackish water to marginal marine environments of the Mid to Late Triassic times.

Although the main focus of the Block is the Permian and Triassic continental sediments, sites of Rhaetian age – the marine Penarth Group (formerly called the 'Rhaetic', also of Triassic age) – are covered by a separate GCR Block. The Penarth Group sediments were laid down during a relatively short span of time at the end of the Triassic Period (only a few million years in duration) that provide a transition from the Triassic red beds into the marine Lower Jurassic Series (the 'Lias'). **See Hettangian, Sinemurian and Pliensbachian (HET-PBN)**. Owing to the formal definition of the base and top of the Rhaetian Stage, rocks of the uppermost part of the Mercia Mudstone Group, together with the and the lowermost part of the Lias Group are also classed as Rhaetian in age. **See Rhaetian (RTN).**

# Palaeoenvironment and palaeogeography

During Permo-Triassic time, through plate tectonics, the continents moved together to form the supercontinent Pangaea ('all Earth'), a single landmass that extended virtually from pole to pole, and which allowed animals to migrate unimpeded from what is now 'Australia' to what is now 'Canada'. Later, towards the end of the Triassic Period, break-up of Pangaea began, and the incipient North Atlantic Ocean began to open up between what we now know as 'Europe' and 'North Africa' on the one side, and 'North America' on the other.

The Permo–Triassic basins of the western UK follow a roughly north–south linear rift system, the Clyde Belt, which was strongly influenced by the underlying structural grain. A number of different rift systems can be identified that contain a large number of individual basins, typically with a basin fill of 1–4 km of mostly continental red beds and evaporites. Major earth movements continued from Late Carboniferous into Early Permian times, particularly in the south of England. These earth movements, part of the Variscan or Hercynian phase of mountain building (**see Variscan Structures of South-West England (VAR-STR-SW)**), resulted from Gondwana moving northwards against Laurasia. Suturing took place along a line within the current Mediterranean Sea, but the resultant north–south compression propagated northwards into southern England, Wales, and Ireland.

There were also immense changes in climates as well as in palaeogeography. The Permian Period began with a major glaciation in Gondwana (a southern hemisphere supercontinent that had fused with Laurasia to form Pangae). The glaciation began in the Carboniferous Period and came to an end during the Early Permian Epoch. Elsewhere, climates throughout the Permian and Triassic periods were generally hot, and conditions commonly arid. Indeed, much of the classic Permo–Triassic succession in Great Britain, and elsewhere, consists of 'red beds', sediments laid down in generally hot conditions either in deserts or in rivers and

lakes, their predominant red-iron coloration attesting to the highly oxidizing environments in which they accumulated.

Permian rocks occur widely in the British Isles, in a number of separate ancient depositional basins, from the Hebrides and west of Scotland, through the English Midlands, to Devon. In places, the successions are entirely continental, but in others there is a change from earlier, broadly continental, sedimentation, to later, broadly marine, deposition. There are also volcanic rocks of Permian age at some localities.

The Triassic succession of Great Britain is divided into a number of stratigraphical units that are generally hard to assign confidently to the Lower, Middle, and Upper Triassic divisions.

The upper boundary of the Triassic System is defined by the base of the Jurassic System, which is internationally recognized as being at the base of the planorbis subzone of the planorbis Ammonite Zone of the Hettangian Stage. The lowest few metres of the Lias, the ‘Pre-planorbis Beds’, are regarded as Triassic in age.

The classic terms ‘Bunter’ and ‘Keuper’ have been abandoned. Formations recognized in Triassic sequences in Britain constitute three major lithostratigraphical units, the Sherwood Sandstone Group, the Mercia Mudstone Group (largely equivalent to the old ‘Keuper Marl’), and the Penarth Group that are applicable throughout most of the British Isles.

## Outcrop pattern

Three main structural trends are recognizable from a map of the main Permo–Triassic basins in the UK: Variscan (east–west), Malvernoid (north–south), and Caledonoid (NE–SW). Broadly speaking these reflect the changing pattern from southern England to Scotland.

1. Wessex and English Channel Basin System

The Wessex–Channel Basin System comprises a number of sub-basins: from south to north the Lyme Bay, Dorset, Wardour, and Pewsey basins, all with an overall east–west trend reflecting formation by extensional re-activation of Variscan compressional structures

2. Worcester Basin and Severn–Bristol Channel Basin

The Worcester Basin is a north–south graben system bounded to the west by the East Malvern Fault/ Only youngest Triassic rocks are seen on the west Somerset and South Wales coastlines, bordering the Severn–Bristol Channel Basin, and in the Mendip Hills where some deposits are confined to fissures in the Carboniferous Limestones. In Glamorgan, marginal alluvial fans were sourced from ridges of Carboniferous Limestone and prograded southwards towards the Bristol Channel.

3. East Midlands–Southern North Sea (SNS) Basin

The East Midlands shows little structure compared with the more westerly basins and the only syndepositional faults lie offshore.

4. Cheshire Basin–East Irish Sea Basin

The Cheshire and East Irish Sea basins constitute part of the Clyde Belt, a NW–SE-trending chain of deep Triassic troughs stretching from the Highland Boundary Fault to the Cheshire Basin. The formation of these basins has been linked with an episode of extension associated with an early phase of Atlantic opening.

5. Vale of Eden Basin

The Vale of Eden is a north–south-trending fault-bounded basin flanked to the east by Carboniferous and Lower Palaeozoic rocks of the Askrigg and Alston blocks.

6. Southern Uplands

In the Southern Uplands of Scotland, Permian deposits rest unconformably on Lower Palaeozoic rocks in a series of basins with a mainly NNW–SSE trend, more or less normal to the regional Caledonian trend. This series of basins, which includes the Moffat, Dumfries, Thornhill, Stranraer, and Lochmaben basins, is similar to the north–south Carboniferous and Permian basin system that cuts the Mid North Sea High.

These basins are, like those in southern Britain, controlled by the structural grain of the basement rocks and are dissected by later faulting.

7. Moray Firth

The Moray Firth Basin is a NE–SW-trending basin strongly controlled by the underlying Caledonian structural grain. There is a large array of faults that were re-activated during Mesozoic extension and that controlled the deposition.

8. Minches Basin

In north-west Scotland are a number of Triassic basins that are mainly known from offshore wells and seismic exploration. These form the Hebrides–Sea of Hebrides–North Minch Basin, a NNE–SSW-trending complex controlled by major Caledonian faults. Outcrops of the Stornoway Formation on the islands of Mull, Skye, Raasay and Lewis occur within the basin.

## GCR site selection

This GCR Block includes sites that were selected for the GCR because of their special significance in the study and understanding of British Permian and Triassic Red Bed stratigraphy, sedimentology, palaeogeography and palaeontology. Sites of scientific interest for their marine Permian rocks were afforded their own site selection category (**see Marine Permian (MAR-PER)**). British Permian and Triassic stratigraphical GCR networks are based on the sedimentary basins.

Permian Strata

- Moray Firth Basin
- South-west Scotland
- North-east England
- West Cumbria
- Vale of Eden
- English Midlands
- Devon

Triassic Strata.

- Moray Firth Basin
- Western Highlands and Islands and Araran
- West Cumbria and the East Irish Sea Basin
- Cheshire Basin
- western margin of the North Sea Basin
- Central Midlands
- Severn Basin
- Devon

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. Sites of Permian and Triassic age important for fossils of fishes, amphibians, reptiles, mammals and arthropods were also selected independently for their own 'Blocks' in the GCR, owing to the relative rarity of fossils of this type. **See Arthropoda (APD); Jurassic - Cretaceous Reptilia (JUR-CRE-RP); Mesozoic Mammalia (MES-MAM); Mesozoic Palaeobotany (MES-PALBOT); Mesozoic - Tertiary Fish/Amphibia (MZ-TR-FI-A); Palaeoentomology (PALENT)**

## Palaeontology, fauna and flora

Life had flourished essentially unchallenged during the Carboniferous and Permian periods: crinoids, corals, nautiloids, ammonoids and fishes diversified in the seas, and amphibians and mammal-like reptiles continued their invasion of the land. However, after more than 100 million years of relative stability, the end of the Permian Period was marked by huge changes to the life of the time; these were far more devastating than the much more famous end-Cretaceous mass extinction when the dinosaurs died out.

The end-Permian mass extinction was by far the largest ever on Earth. Perhaps as many as 96% of all marine species became extinct, while on land more than three-quarters of all vertebrate families were lost; only 4% of known species survived through the event into the Triassic Period. This is the nearest that life on Earth has yet come to total annihilation.

Although there is little fossil material in the red beds at the Permian–Triassic boundary in Britain that exemplify the impact on the fauna and flora, comparisons of the fossil record from marine Permian rocks and marine Triassic rocks reveal the extent of faunal changes. In the sea, reefs were destroyed, and with them disappeared the last of the rugose and tabulate corals, as well as major groups of bryozoans, echinoderms, foraminifera, ostracods, brachiopods, gastropods, bivalves, ammonoids, nautiloids, and fishes. This huge 'clear-out' of classic Palaeozoic animals opened the way for new groups of corals to arise later in the Triassic Period, and for previously minor groups of bryozoans, bivalves, echinoderms, and ammonoids to come to the fore.

On land too, the end-Permian mass extinction destroyed the complex ecosystems of amphibians and mammal-like reptiles, and left only remnants behind in the earliest Triassic times, from which arose the dinosaurs, pterosaurs, marine reptiles, and mammals. Some of these terrestrial forms appear sporadically in the fossil record, either as skeletal remains or as footprints in the British Permo–Triassic red beds, but the record is sparse.

The magnitude of the crisis is indicated by the recovery phase in the Triassic Period. Whole habitats had gone and took millions of years to return. For example, it took 20 million years before new kinds of reefs became re-established, being built, of course, by organisms different from those that built the Permian reefs. After the end-Permian event there is a famous 'coal gap', when no coal is found at all: the forests had been devastated, and burial of plant material in significant quantites came to a complete halt for 20 million years. The diverse and complex ecosystems of mammal-like reptiles, including massive, rhinoceros-sized plant-eaters, and sabre-toothed gorgonopsians that preyed on them, were gone, and only some small to medium-sized amphibians and reptiles inhabited the Early Triassic world. However, 30 Ma later, ecosystems had begun to diversify on land again, and this coincided with the radiation of the dinosaurs.

There was another planet-wide extinction event at the end of the Triassic Period, about 205 Ma ago, when many diverse groups of plants, animals, and microbes suffered unusually high levels of extinction.